JAMES COOK UNIVERSITY
AUSTRALIA

Adaptive Capacity of Islands of the Maldives to Climate Change

Ibrahim Mohamed
Master of Applied Science in Protected Area Management
Bachelor of Science (Biology and Chemistry)

A thesis submitted for the Degree of Doctor of Philosophy at the James Cook University in November 2018
College of Science and Engineering

To my love, Aisha, and our island princess, Balqees

Acknowledgements

To my dearest love, Aisha, for the love and inspiration, for all the tears and long waits, for being my companion and for always being patient. Thank you for sacrificing so much and giving me unconditional love, and sincere support and prayers throughout this journey. NO words can thank you enough.

For my loving daughter, Balqees, who made life enjoyable even during the hardest times. The hugs when I leave to go to University and the waiting for bed time stories made every day special. I hope you will soon understand why Daddy needed to spend a lot of time at Uni.

I would like to thank the communities of Ukulhas, Bodufolhudhoo, Hanimaadhoo, Vilufushi and Fuvahmulah islands, and the people who took part in my research and assisted in many ways. I would like to mention Shaukath, Salaam, Nasih and Mohamed for their assistance. Also, I thank the Island Councils of these islands for their support. I also would like to extend my thanks to Ministry of Environment and Energy and Climate Change Department and staff and colleagues.

My supervisors: David King and Alison Cottrell, thank you for the trust, support, guidance, and for the significant contributions to my thesis. Thanks also to Kevin Parnell for his guidance during the initial stages of my PhD. I would like to acknowledge the support of College of Science and Engineering, and the admin staff for their kind support. I also recognise the support of department of Foreign Affairs and Trade of the Commonwealth Government of Australia and the Australia awards team.

I also take this occasion to mention Ali Najeeb for inspiring me, by setting an example for me, and for supporting me like a brother.

To my mum, Hawwa Hassan, and dad, Mohamed Shaugee, for their immense efforts to educate me and my siblings. To my younger siblings who always made me feel so special. To my elder siblings, my maternal uncles and aunts, and my paternal uncles and aunts for their encouragement. Many thanks to my Uncle Ali Wafir for his wisdom and advice as a mentor.

A special thanks to my mum in-law for being so patient and kind to let her daughter to accompany me, far away from the family. Thanks to all my in-laws for their support to me and our little family.

Teimoor for the advice and great company during the tea and coffee breaks.

Hassan Emaan for helping me visualise my research in a beautiful picture.

David and Suri for being our family of Townsville. Gordon, Elaine and Rory for the special times. To Peter and Ladta for the good company. To Graeme for the prayers and wisdom. To the family of Paheeratna for our everlasting friendship.

I'm grateful for My colleagues from EPA, and MEE, especially Mr. Zahir (MZ) for being my mentor and Mr. Moosa Jameel for his assistance and support.

I like to thank my friends in academia, Icha, Teimoor, Nabeeh, Rifaee, Monica and Pranavan, Rie, Taka, Shumais, Jenny and several others whom cannot be listed in this space. Special thanks to Dr. Venkat Jee.

Thank you to all my friends and my whole family who have helped me in so many ways.

To my mum … thank you for your prayers, sacrifice and love! With God's grace I have finally made it!

Statement of contribution of others

Thesis supervision and editorial support:

- Associate Professor David King
- Associate Professor Alison Cottrell

Additional analytical and editorial support:

- Dr. Putu Liza Mustika
- Dr. Venkat Vangaveti
- Dr. Takahiro Shimada
- Dr. Rie Hagihara
- Dr. Monica Gratani
- Dr. Jennifer Atherton

Research funding:

- Department of Foreign Affairs and Trade of Commonwealth Government of Australia through, Australia Awards Maldives office, full PhD scholarship and all academic related support.
- College of Science and Engineering of James Cook University provided a write-up grant.

Research assistance during data collection:

- Mr. Ahmed Murutaza, Director General, Ministry of Environment and Energy

Abstract

In today's world, small islands are exposed to unprecedented impacts of global climate change. The ability of small islands to adjust and cope with these impacts is based on a number of socio-ecological parameters. Research on adaptive capacity has gained momentum within the last decade, and opted assets-based theories, correlating adaptive capacity to utilisation of available opportunities and resources. While such methodologies have major limitations, there is a dearth of studies on adaptive capacity of small islands at the frontier of global climate change. The small island nations are threatened with loss of culture and disruptions to livelihoods, as well as ability to support human habitation from the predicted future effects of climate change.

This thesis provides information on this life and cultural threatening issues by identifying the potential for, and limits to, climate change adaptive capacity in the islands of the Maldives through a lens of islandness. This thesis employed a multidisciplinary theoretical framework and contributed to a holistic understanding of adaptive capacity of small islands. The study utilised theory of islandness from an epistemological perspective of pragmatism. The concurrent mixed methods approach, based on analogue comparative case study methodology, involved both constructivist and positivist approaches. The study examined five case study islands from the Maldives and triangulated data obtained from document analysis, participatory climate change adaptation appraisal, stakeholder interviews, surveys, and spatial analysis of biogeophysical characteristics.

The results of this study demonstrated that adaptive capacity of islands is a predicament of the biogeophysical characteristics, socio-politics and governance, socio-cultural, and socio-economic factors. The analyses revealed that: (1) the most critical influence on adaptive capacity is from biogeophysical characteristics of islands, followed by socio-cognitive aspects related to belief efficacy of islanders; (2) at a household level, assets, social organisation and flexibility contributed significantly to adaptive capacity; (3) the islands are currently approaching their adaptive capacity thresholds, owing to non-linearity of responses of biogeophysical features of islands to ongoing climate change impacts, especially increases in temperature, sea level rise and changes in rainfall; (4) islands at the edge of crossing the adaptive capacity thresholds require engineered transformative adaptation; and (5) transformation of adaptive capacity into adaptive actions requires empowerment of islanders,

democratisation of institutions, and strategic planning of hard and soft adaptation measures within an island context and scale.

Consequently, encoding and decoding of adaptive capacity from an island epistemological view defines what socioecological aspects, and by which strategies, adaptation can be mobilised and enhanced. Emergent findings indicative of future research includes incorporating ethnography with phenomenology in the study of adaptive capacity and refining the methods used in data collection. Additionally, the present research confirmed that an adaptive capacity index does not translate how the adaptive capacity can be mobilised in to action in islands, and is not significant. The results of this thesis offer significant contribution for policy makers and adaptation practitioners on how climate change policies and strategies need to commensurate with the context of the dynamic socio-ecological system of the islands. The present study also offers an insight of strengths, limitations and challenges on islands in adapting to future climate change.

Contents

List of Tables

List of Figures

CHAPTER 1: INTRODUCTION

1.1 Introduction to the study

The challenges resulting from unprecedented changes to human societies make adaptive capacity crucial for their sustainable future (Millenium Ecosystem Assessment, 2005). The complex socio-ecological systems which encompass human societies and natural systems can adapt in reactive and anticipatory manners (Engle, 2011). Adaptive capacity of these socio-ecological systems must be examined to understand how the systems will cope and adjust to future changes, such as global climate change. Recently, interest in determining the adaptive capacity of human societies in responding to global climate change has gained momentum (Mortreux & Barnett, 2017), and their vulnerability and resilience has received considerable critical attention. In light of recent unprecedented changes experienced by small island societies, understanding the enormous challenges to these societies is essential (Wuebbles, 2013). Small island states, such as the Maldives, are among the most vulnerable in the face of climate change, making adaptive capacity vital for their sustainable future.

1.2 Study Background

My interest in this research developed from being an islander myself and working on adaptation projects in the islands of the Maldives. This research was conceived while I was working for the Maldives Climate Change Trust Fund project as an Environmental and Social Safeguards Officer. During my field work in the islands, I began exploring the threats and opportunities for island communities in adapting to future climate change. I discovered that perceptions on climate change risks and adaptation are an embodiment of the lived experiences of islanders. I also uncovered that, despite the vulnerability of islands, people are committed to continuing to live on their islands. Consequently, my interest to explore and understand the adaptive capacity of islands of the Maldives for future climate change made me embark on this research.

Although the increase in global warming was recognised by a few scientists from the 1930s onwards, it was not well acknowledged until the 60s and 70s (Weart, 1992). Weart (1992) found that, Charles Keeling's measurements of global carbon dioxide levels in Mauna Loa in Hawaii in 1961, became a major turning point for climate scientists. In a similar finding in 1986, Swedish Scientist, Arrhenius, estimated that doubling of the industrial emissions of carbon dioxide in the atmosphere could increase global temperature by 4-6 degrees Celsius (Weart, 1992). Following this and other similar studies, many scientists began embracing climate change as a logical consequence of emissions from fossil fuel burning, leading to global climate change phenomenon; meanwhile many societies also continue to believe climate change to be a natural phenomenon or a divine retribution (Weart, 1992).

Climate change and the resulting impacts are now well recognised in the realm of scientific research. Wuebbles (2013) argued that, globally, many societies over time have developed resilience to deal with the climate variations, indicating the ability of human societies to utilise resources to adapt. However, the industrial emissions keep increasing beyond the coping capacity of most socio-ecological systems, requiring urgent and persistent actions to avoid serious consequences from a rapidly changing climate (Wuebbles, 2013). As a global response for action, the Paris Agreement was adopted by a majority of nations in 2015 to reduce the global average temperature below 2˚C relative to pre-industrial levels (Tanaka & O'Neill, 2018). However, according to available scientific evidence and major findings, even if a temperature lower than 2˚C above pre-industrial levels is achieved, a rise in sea level above 1.5 metres by 2300 is still highly possible (Mengel, Nauels, Rogelj, & Schleussner, 2018), while the world is currently facing temperature anomalies not experienced on Earth for millions of years (Watts, 2013). Even with major efforts and commitments, such as the Paris Agreement, the Earth's climate may shift beyond the limits to which the natural and human systems have become adapted over several centuries (Watts, 2013). Watts (2013) found that most scientists agree on the fundamental science and climate change phenomena. Hence, a consensus on the cause of global warming has been reached, especially with the 2015 Paris Agreement. Meanwhile, few sceptic views found in literature still argue on the validity of long-term scientific data and certainty of predictions of climate scientists and the modelling conducted by the IPCC (Watts, 2013).

The Fifth Assessment Report of the Working Group II of the IPCC (2014) stipulates that, small island nations are among the most vulnerable and that, the atoll nations face the highest risk of sea level rise. Consequently, many coastal and low-lying areas are faced with severe threats of submergence, coastal flooding and unprecedented erosion. Crucial climate drivers for small islands, emphasised in the IPCC (2014) report, include variations in temperature, ocean biochemistry, rainfall, wind speed and direction, wave patterns, extreme weather, droughts, and sea swells. In addition, risks were identified in major changes in coastal marine systems, such as coral reefs and coastal wetlands, terrestrial biophysical systems, and fresh water systems. Similarly, social systems are also at stake, with possible severe impacts on infrastructure, tourism health, and local economies. Consequently, relocation and migration is becoming crucial, owing to loss of land due to consequences of climate change impacts (Intergovernmental Panel on Climate Change, 2014c).

The IPCC (2014) projections for the year 2100 indicate an increase in surface temperature by 1.2-2.3°C in comparison with 1986-2005 baselines. Additionally, the predictions also indicate an increase of precipitation level from 1-9 percent in the Indian and Pacific Oceans where many small islands are located. By 2100, the sea level for central and western Indian Ocean regions is expected to increase by 0.5-0.6m above 1986-2005 baselines (IPCC, 2014c). These future climate variations could have devastating consequences for small low-lying island nations like the Maldives. Future projection estimates were determined for variations in climate patterns for the Maldives in a down-scaled model, produced by the government of the Maldives (Srinivasan, Jothiganesh, & Subbiah, 2012). The model projections indicated sea level, sea surface temperature and rainfall variations as the most significant future threats. The model predictions suggested that in the next 20-30 years, the average rainfall, maximum daily rainfall, and number of wet days will increase throughout the Maldives. Additionally, an increase in sea surface temperature throughout the country, with an increase of sea level by 0.8 to 0.9m by 2080 was also recognised. However, sea level data cannot be interpreted with certainty, as land elevation and bathymetry data are not available for the entirety of the Maldives (Srinivasan et al., 2012). With 80 percent of islands merely a metre above the mean sea level, and 44% of settlements within 100m of coastlines, nearly half of the population is under threat from increased sea level. Furthermore, the only freshwater resource, which is underground on the islands, may be completely salinized, resulting in devastating consequences (Ministry of Housing Transport and Environment, 2009). These results indicate that a sustainable future for the islands of the Maldives is bleak unless efficient adaptation measures are developed to respond to these threats.

The Fifth Assessment Report of the IPCC also highlighted the dearth of literature on adaptive capacity of small islands with limited evidence-based research on risks and consequences of climate and adaptation measures required. According to the IPCC, constraints in financial, technological and human capacity, as well as culture, ethics, knowledge and attitudes, act as barriers to adaptation in small islands. Meanwhile, due to the compounding effects of vulnerable natural characteristics of islands and manmade pressures, isolating climatic effects from human disturbances is highly challenging (IPCC, 2014c). Consequently, assessment of adaptive capacity in small islands is crucial to understand the thresholds and limits of island socio-ecological systems in responding to future climate change.

1.2.1 Research Objectives

This research aims to fill the gap in literature on adaptive capacity of small islands to adapt to global climate change by fulfilling the following objectives:

- *To understand how adaptation is taking place on the islands*

This objective establishes the research methodology based on an island-centred pragmatic approach for studying the adaptive capacity.

- *To identify who is adapting and what the motivations for adaptation are*

The preceding objective postulates the empirical evidence from the case study islands on adaptive capacity and validates and verifies the effectiveness of outputs of objective one.

- *To assess the determinants which enhance adaptive capacity in the islands*

This objective also supports objective two by providing details on adaptive capacity of islands based on critical determinants within an island context.

- *To assess how knowledge, resources and institutions influence adaptive capacity*

This objective also supports objective two by providing a synthesis of adaptive capacity of islands based on empirical evidence on institutional aspects of islands.

- *To understand variation of adaptive capacity on islands*

The preceding objective answers the call for an adaptive capacity measure based on household level indicators of adaptive capacity.

1.3 Statement of the problem

The State of the Environment of the Maldives (2011), recognised the island state of the Maldives is highly vulnerable to climate change impacts. The country is made up of coral atolls of 1,190 islands, with an average size of 0.5-2 square kilometres, making it highly vulnerable. There are 193 inhabited islands with a total population of 319 thousand. About 80% of the land is merely a meter above sea level, posing overwhelming threats of submergence and coastal flooding, exacerbating vulnerability. Meanwhile, the technical knowledge and understanding of coping with future climate change is poor, while there is also a lack of financial and human resources to cope with the challenges (State of the Environment, 2011). Due to the severity of threats of climate change, it can be stated that a sustainable future for the Maldives' islands is highly threatened, due to their lower adaptive capacity and high vulnerability. Hence, it can be hypothesised that lower adaptive capacity can impede transformative adaptive capacity, while vulnerability, lack of preparedness and ability to adjust to disturbances from extreme events can have compounding effects on adaptive capacity. Consequently, adaptive capacity of islands is directly related to variables such as governance, policies, management, and resources available and is inversely related to climate change impacts. The study will explore how such factors enhance or limit adaptive capacity on the islands. In addition, this research also aims to understand the potential for and limits to climate change adaptive capacity in the islands of the Maldives.

1.4 Nature of the study: Research Methods

This study was carried out using a convergent parallel mixed methodology. In this method, both qualitative and quantitative methods are used to solve the research problem and analysis is triangulated by transformation of data to arrive at a conclusion (Creswell, 2014). The methodology used for this applied research lies on an ontological paradigm of pragmatism, in a post normal context (Collins, Onwuegbuzie, & Jiao, 2007). This approach was utilised to incorporate an island centred framework to understand the multi-dimensional aspects of adaptive capacity on islands.

In this research, adaptive capacity of small islands was explored using a mixed method approach, by conceptualising islands as a socio-ecological system. Adaptive capacity is a complex, nonlinear, latent and interdisciplinary phenomenon which requires quantitative and qualitative analysis based on external objective observations and subjective interpretation of people's experiences (Engle, 2011). In this thesis, quantitative methods were used to understand the correlational and probabilistic aspects of adaptive capacity. On the other hand, qualitative methods were used to understand subjective and objective aspects of adaptive capacity through socio-economic, socio-cognitive (Grothmann & Patt, 2005), and institutional and governance aspects (Engle & Lemos, 2010) within the island communities. Consequently, both a positivist approach of objective observations and a constructivist approach of subjective interpretations were utilised to draw research inferences (Creswell, 2014).

In this mixed method research, an analogue comparative case study methodology was utilised. To explore the influence of the determinants of adaptive capacity, Participatory Climate Change Adaptation Appraisal (PCCAA) involving focus groups was utilised with key informant interviews. In addition, factors contributing to adaptive capacity of households were explored. To understand causation and correlation of biogeophysical factors influencing adaptive capacity, spatial analysis using Geographic Information System (GIS) was utilised.

1.5 Conceptual framework

Adaptive capacity is subjective and context dependent and, hence, a conceptual model encompassing natural and social capital of islands must be formulated. To derive a conceptual framework for the research, an integrated approach was utilised by employing both resilient and vulnerability frameworks. In this study, I decided to utilise the vulnerability framework to characterise adaptive capacity using exploratory qualitative data instruments to determine independent variables that influence the adaptive capacity (Engle, 2011). Thus, adaptive capacity deficits and factors which cause these deficits were identified, as well as potential for emergence of such deficits in the future (Williamson, Hesseln, & Johnston, 2012). From the exploratory phase findings, indicators of adaptive capacity were verified and assessed quantitatively through household surveys, to determine commonalities and differences in adaptive capacity of island communities.

1.6 Research Questions

Key guiding questions for this research are based on the context of small islands' socio-ecological system. Each of the following questions is based on a hypothesis testing, to postulate adaptive capacity of islands based on the mixed methods approach utilised in this thesis. The questions examined were:

1. What are the socio-economic, biophysical and governance variables which contribute to the adaptive capacity of small islands?
2. What variables have the greatest influence on the adaptive capacity thresholds of small islands?
3. What is the degree of adaptive capacity and resilience of the islands to the long-term impacts of climate change?
4. What are the climate change impacts predicted to affect the islands beyond their adaptive capacity?

1.7 Thesis outline

The overall structure of this thesis is formed into eight chapters. The first chapter provides an overview of the thesis followed by literature review and methodology chapters. This is followed by the four results chapters providing the major findings of the study. Following the analysis chapters will be the main discussion and conclusion chapter of the thesis.

Chapter Two: Literature review

This chapter unpacks the terminologies and theories developed to study adaptive capacity, and presents a synthesis of studies on adaptive capacity of vulnerable and marginalised communities, and how communities cope and manage climate change impacts. The chapter also presents a review of literature on approaches, frameworks and methodologies, exploring the concepts and terms. According to the literature review, framing adaptive capacity of islands, by integrating a livelihoods framework with local adaptive capacity framework conceptualised within a socio-ecological context, will provide a robust methodology to characterise and evaluate adaptive capacity of islands. The review also indicated importance of using a mixed methodology, emphasising both constructivist and positivist paradigms.

Chapter Three: Method & methodology

Chapter three presents an examination of methods and methodology based on the conceptual framework derived for the study. The exploration of adaptive capacity based on an integrated resilience and vulnerability framework provided the theoretical foundation of the thesis. This was further reinforced by the mixed methods approach based on case studies to understand adaptive capacity by utilising multiple data sources to triangulate data (Yin, 2009). The multiple data sources provided rich data, justifying the case study methodology. The qualitative data were reinforced with quantitative methods measuring and exploring adaptive capacity through a set of predictor variables. Accordingly, a convergent parallel mixed methodology, as given by Creswell (2014), was utilised in this thesis to fulfil the research aim of identifying the potential for and limits to climate change adaptive capacity in the islands of the Maldives.

Chapter Four: Major determinants and endowments of governance and institutions in enhancing adaptive capacity

In this chapter, the influence of governance, and institutions that effect adaptive capacity in the Maldives, was explored.

Chapter Five: The role of social discourse and socio cognitive factors in climate change adaptive capacity of Maldivian Islands

In this chapter, a socio-cognitive model of adaptive capacity was tested to understand how socio-cognitive aspects and belief efficacies contribute to adaptive capacity.

Chapter Six: Synergies and trade-offs and approaching barriers and limits on adaptive capacity

In this chapter, the biogeophysical barriers and limits resulting in adaptive capacity thresholds were analysed.

Chapter Seven: Measurement of adaptive capacity of households

This chapter involved quantification of indicators which contribute to adaptive capacity of island households, based on a set of indicators fitted within the five domains of assets, social organisation, flexibility, learning, and agency.

Chapter Eight: Conclusions and implications

In this chapter, the initial research problems and questions were revisited, and the implications of the findings on adaptive capacity were delineated. The implications for theory, methodology and policy were discussed.

CHAPTER 2: LITERATURE REVIEW - ADAPTIVE CAPACITY OF ISLANDS TO CLIMATE CHANGE IMPACTS

2.1 Introduction

This chapter presents a comprehensive literature review on the discourse of adaptive capacity of small islands to climate change. The chapter begins with a review of extant literature on climate change predictions and impacts on small islands in the context of the Maldives. This is followed by a discussion on barriers and limits to adaptive capacity in an island context, specific to the Maldives, such as the social, cultural, political, and governance aspects. Afterwards, definitions, major theoretical perspectives, and determinants of adaptive capacity are critically reviewed to identify key theoretical issues and limitations in determining adaptive capacity. Finally, a review of methods on evaluating adaptive capacity and studies related to this thesis is provided.

To build up a concise and logical argument, this literature review is divided into sub-sections (Table 2.1): (1) climate change impacts in a small island context specific to the Maldives; (2) adaptive capacity barriers and limits in a Maldivian context; (3) defining adaptive capacity; (4) determinants of adaptive capacity; (5) theoretical perspectives on adaptive capacity; (6) analysis of socio-economic and social psychology models to evaluate adaptive capacity; (7) review of different methods of adaptive capacity assessments; (8) synthesis of different approaches in evaluating adaptive capacity; and (9) review of adaptive capacity studies related to this thesis.

1. Table 2.1 Literature review structure

Section	Title	Description
2.2	*Climate change and small islands in the context of Maldives*	In this section, climate change is defined, and the physical vulnerabilities of small islands based on the IPCC predictions and scenarios and local data from a downscaled model is evaluated for the Maldives. In addition, the socio-culture, socio-politics and socio-economics of the Maldives is analysed to instil linkages of these aspects with adaptive capacity of islands of the Maldives.
2.3	*Changing the discourse from vulnerability to adaptive capacity*	This section provides an analysis of the discourse of vulnerability within an island context and a critical review of importance of paradigm shift to adaptation and capacity of islands is given.
2.4	*Defining adaptive capacity*	This section defines the concept of adaptive capacity and examines the quagmire of defining the term due to the multitude of spatial and temporal aspects.
2.5	*Analysis of determinants of adaptive capacity*	This section examines the determinants and indicators of adaptive capacity and the methods used in measuring the indicators at different scales from micro to macro levels. It gives a basis for including a multitude of determinants from different dimensions of social and ecological facets.
2.6.1	*Theorizing adaptive capacity*	In this section, different theories which underpin adaptive capacity are examined and is critically reviewed to determine the most suitable model to evaluate adaptive capacity of islands.
2.6.2	*Framing of adaptive capacity*	This section examines framing of adaptive capacity based on different approaches and conducts a comparative analysis of various frameworks used in adaptive capacity assessments.
2.7	*Synthesis of adaptive capacity evaluation from different approaches*	This section analyses different approaches in conducting adaptive capacity research frameworks of vulnerability and resilience of socio-ecological systems within the livelihoods.
2.8	*Adaptive capacity research from literature*	This section provides a comprehensive analysis of major studies from literature related to this thesis.
2.9	*Summary*	This section provides a summary and rationale for choosing a convergent parallel mixed methodology with an integrated framework for analysis of adaptive capacity of islands.

2.2 Climate change and small islands and the context of the Maldives

The Article 1, paragraph II, of the (United Nations Framework Convention on Climate Change (UNFCCC) 1992): defines climate change as *"A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".* However, the scientific body of UNFCCC, the Intergovernmental Panel on Climate Change (IPCC), does not differentiate between manmade and natural causes of climate change in their definition and states that climate change is "any change in climate over time" (Intergovernmental Panel on Climate Change, 2007). According to the *Fifth Assessment Report* (FAR) of Intergovernmental Panel on Climate Change (2014b), most of the impacts of climate change predicted for small islands are of high confidence levels with robust evidence. Nevertheless, the Intergovernmental Panel on Climate Change (2014b) acknowledges the lack of specific, consistent long term data, reliable at local levels for most Small Island Developing States (SIDS). The IPCC (2014) also highlights that, regardless of climate actions taken now, current climate change trends will continue until at least the middle of this century. Meanwhile in 2015, the UNFCC's Conference of the Parties meeting in Paris reached a global consensus on capping global temperature to 2˚C, relative to preindustrial levels (Mengel et al., 2018). However, many critics believe the provision of making it voluntary for signatories to reduce their greenhouse gas emissions in the Paris Accord is a huge challenge to reach the set target, especially after it was revoked by the United States of America. The following sub chapters will explore climate change impacts and scenarios for the North Indian Ocean (NIO) region where the Maldives is located, and predictions and impacts specific to the Maldives.

The current trends and projections, based on the Second National Communication (SNC II) of the Maldives to UNFCCC (2016), will be provided below. Current trends in precipitation, temperature, sea level, and sea surface temperature were analysed based on data from Maldives' Meteorological Services and other assessments. Future projections are based on a scaled down model of Global Climatic Models (GCMs) by the Regional Integrated Multi-Hazard Early Warning System (RIMES) (Ministry of Environment and Energy, 2015). This downscaled model was based on the ability to simulate monsoon precipitation climatology. In this model, predictions were determined based on the IPCC Fourth Assessment Special Report on Emission Scenarios (SRES) as given below and carried out for four geographic zones.

The IPCC 4th Assessment Special Report scenarios are:

1. A2 – high emission scenario used for statistical downscaling.

2. A1B – mid-level emission scenario used for dynamical downscaling.

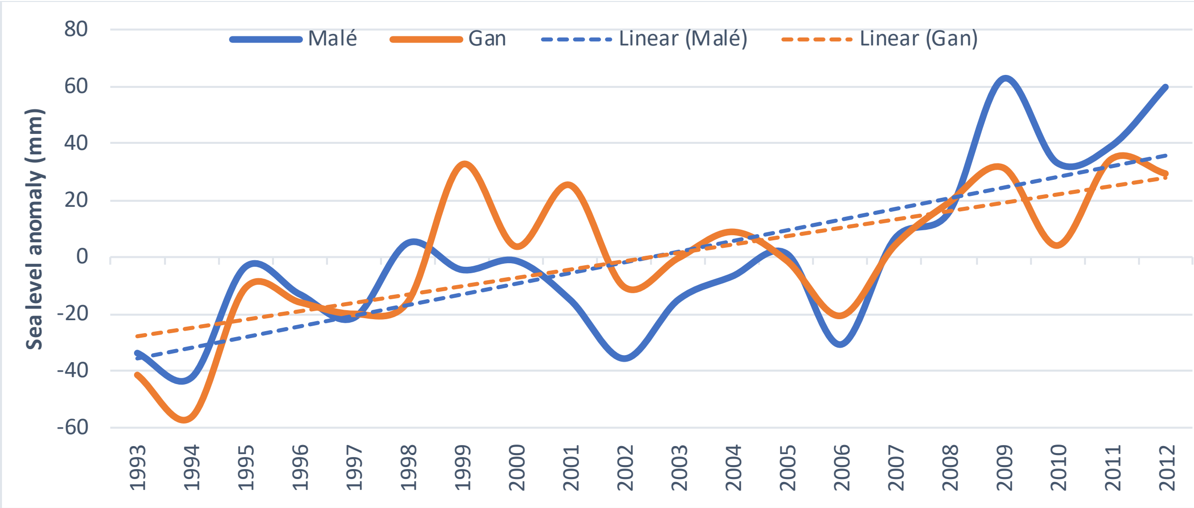
3. B1 – low emission scenario used for statistical downscaling.

2.2.1 Current trends and future projections for Maldives

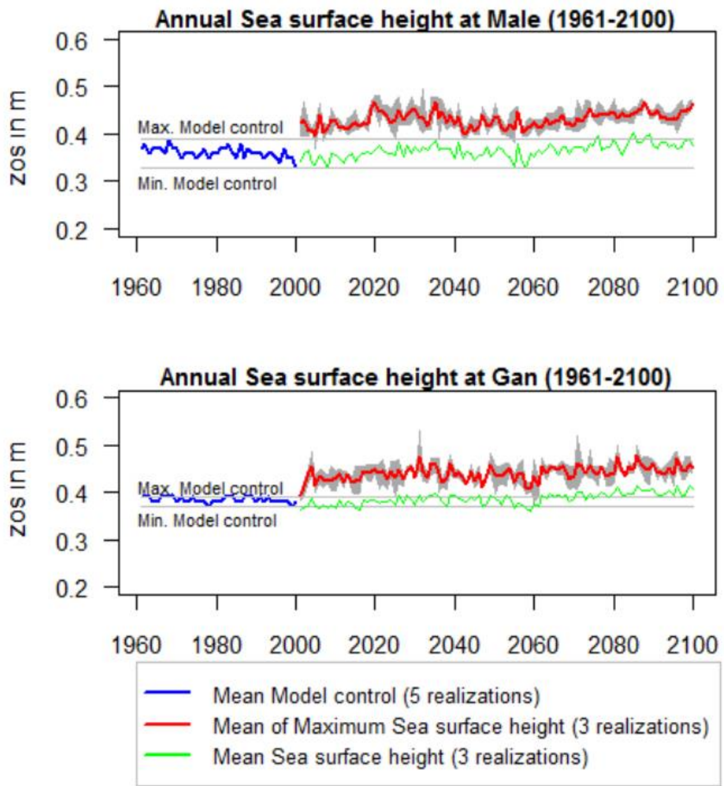
2.2.1.1 Sea level rise

Sea level rise is considered the biggest risk to low lying SIDS, due to major threats to coastal areas and freshwater resources, threatening human habitation on them beyond mid-21st century (Kelman & West, 2009; Storlazzi et al., 2018). According to FAR of IPCC (2014), changing sea level due to climate change is of high confidence. For instance, for an intermediate low emissions scenario for the North Indian Ocean (NIO), it is expected that the sea level rise will be between 0.4 to 0.5 meters by 2080 to 2100, compared to the 1986 to 2005 baseline (Intergovernmental Panel on Climate Change, 2014b). These projections do not consider the rates of Antarctic ice sheet melting, exacerbated by warming and other compounding effects; hence, it is likely that sea level rise will be higher than the conservative estimates. Sea level rise may cause flooding of entire coastal regions, submergence of many islands, and/or severe erosion of low lying areas (Storlazzi et al., 2018).

Current trends in sea level change in the Maldives show that from 1993 to 2012 the sea level increased by 3.75 and 2.93mm per year for the central and southern region, respectively (Second National Communication, 2016). Projections for sea level rise could not be predicted from available data in the Maldives due to small time frame of data; therefore, global models were used in modelling. The global models predict maximum sea surface height changes for central and south to vary between 0.40 to 0.48 metres from 2001 to 2100 with an uncertainty of 0.36 to 0.5m.



1. Figure 2.1 Observed changes in sea-level adapted from Second National Communication Maldives (2016)

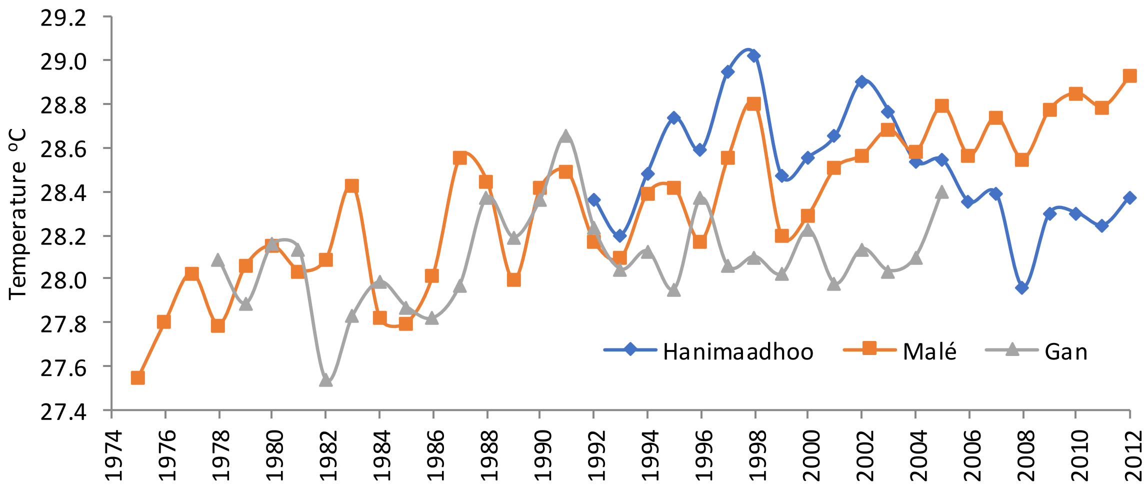


2. Figure 2.2 Predicted sea-level changes by 2100, adapted from Second National Communication (2016)

Studies on physical changes to islands due to sea level rise are limited, even though the predicted sea level rise can have major consequences for human habitations on islands (Kelman & West, 2009). According to Perry et al. (2011) islands, like those in the Maldives, originating from coral sand sediments, will have low levels of resilience to sea level changes above 0.5 meters due to increased island wash over, beach erosion, and dynamic movement of sand around islands. Perry et al. (2011) believed that such dynamic changes are also interlinked with climate change feedbacks related to ocean chemistry and ecology. Hence, the predicted sea level changes will exacerbate the vulnerability of Maldivian islands.

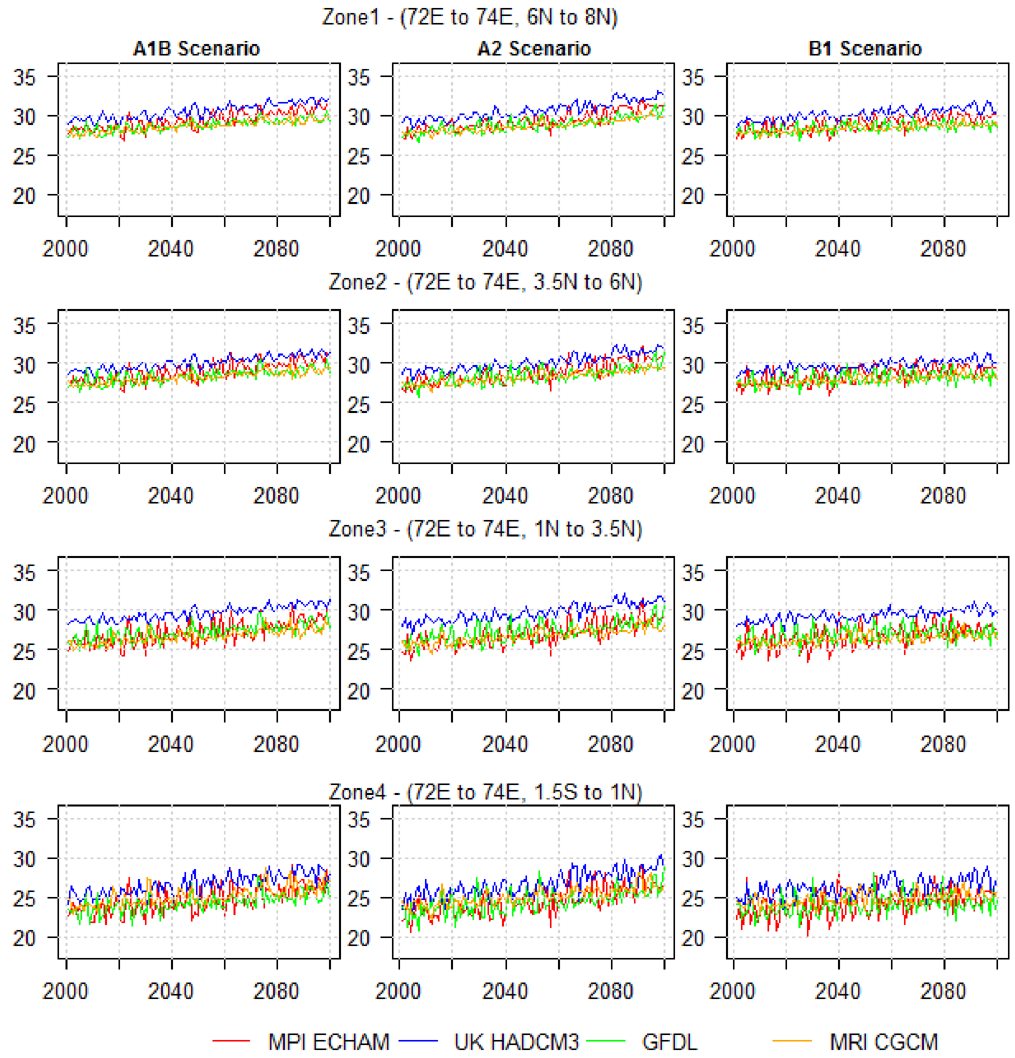
2.2.1.2 Increased surface temperature.

Surface temperature is expected to increase in NIO region by 1.2-2.3˚C by 2080 to 2100, compared to the 1986 to 2005 baseline, according to FAR of IPCC (2014). According to the meteorological data analysis provided in Second National Communication (2016), current trends show that from 1975 to 2012 temperature increased by 0.267˚C/decade for Malé and 0.168˚C/decade for Gan. However, Hanimaadhoo in the northern region showed a small decrease of 0.086˚C/ decade, but since data for Hanimaadhoo is only available for 20 years, uncertainty is high. Assessment of maximum temperature - according to SNC II - indicates an increasing trend in the northern part of the country (0.21˚C per decade), and a decreasing trend (-0.06˚C/decade) in the southern part of the country. Additionally, the minimum temperatures increased by 0.25˚C/decade in the north, while in the south a steep increase of 0.4˚C/decade is observed. Hence, a general increase in temperature is observed in the Maldives. Trends in sea surface temperature per SNC show an increase of 0.11 to 0.15˚C per decade, with a lower increase in the north compared to the rest of the nation.



3. Figure 2.3 Observed changes in temperature for Hanimaadhoo, Malé and Gan from 1974 to 2012 adapted from Second National Communication (2016)

The downscaled model predictions indicate that the mean annual temperature for the period of 2021 to 2050 will be 1.8˚C higher, compared to the base line of 1981-2000. Model predictions also indicate that by 2082 to 2100, northern and central regions will have higher temperatures compared to the southern region. Predictions for sea surface temperature based on records from 1961-1991 showed that there were temperature increases of: 0.76˚C to 1.37˚C for the 2030s; 1.01˚C to 1.93˚C for the 2050s; and 1.27˚C to 3.07˚C for the 2080s. According to these predictions, the sea surface temperature will be higher in the southern region, with an overall increase throughout the nation. Increase in surface temperature and sea surface temperature will have major consequences for the socio-ecological system of the islands.

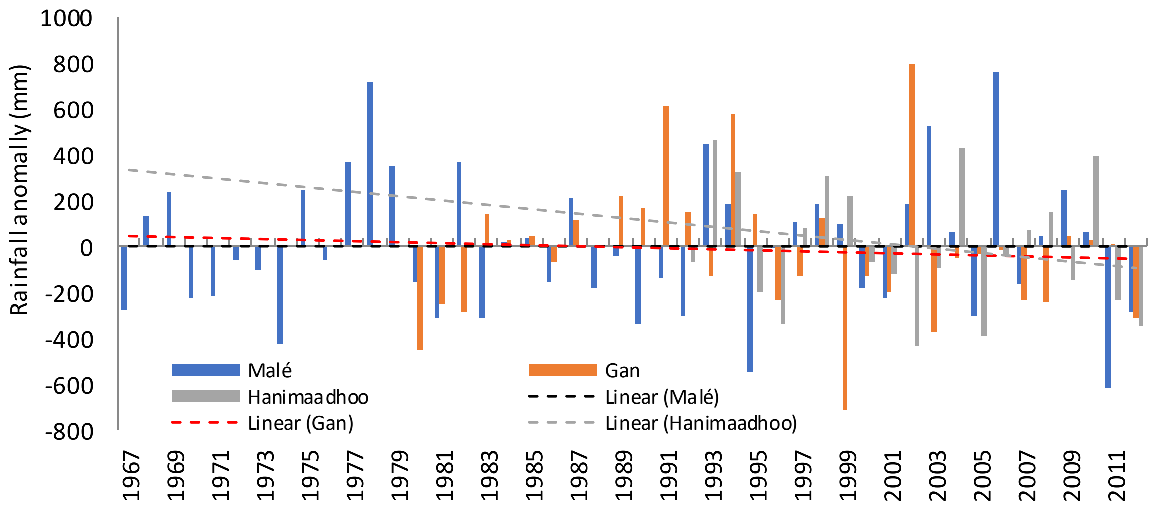


4. Figure 2.4 Predicted changes in temperature for different scenarios by 2100 adapted from Second National Communication (2016)

2.2.1.3 Precipitation

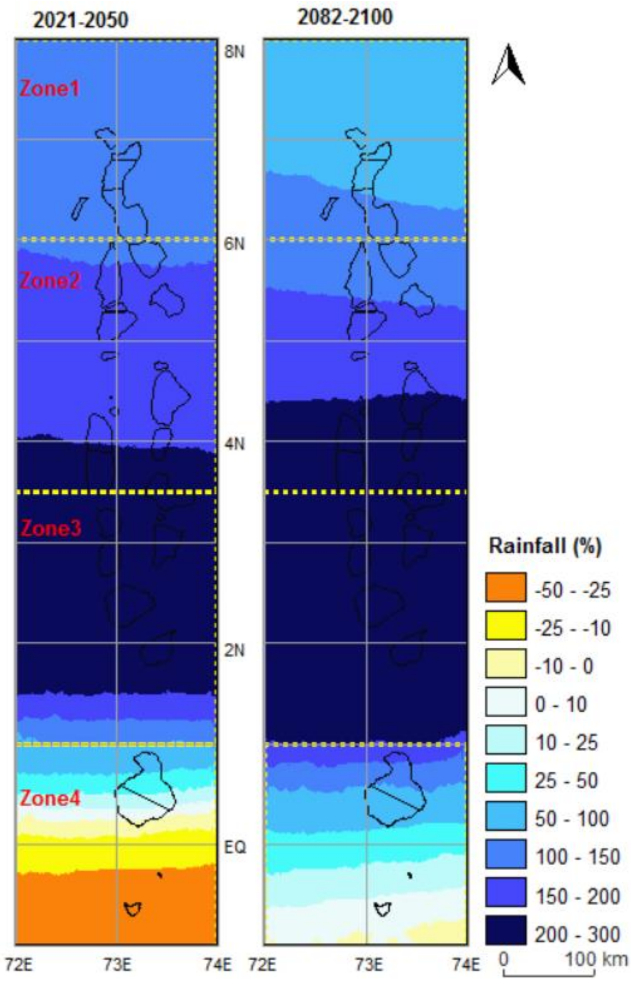
Compared to 1986 to 2005 baseline, rainfall is expected to increase by 9 percent in the period of 2080 to 2100 for NIO, according to FAR (2014) of IPCC. In his PhD Thesis, *The influence of Asian monsoon variability on precipitation patterns over the Maldives*, Zahid (2011) argued that the major impact of climate change on the Maldives will be variations in rainfall patterns. Zahid (2011) recognised that threats of flooding from heavy rainfall, and droughts due to reduced rainfall, can have major consequences for islands. For instance, flooding can cause extensive damages to households and infrastructure, while droughts can cause salinization of freshwater lens and reduced availability of rain water.

Analysis on rainfall provided in SNC (2016), indicated an overall decrease in rainfall per year by 9.5mm; with decreases of 0.02 millimetres and 2.21 millimetres over Hanimaadhoo, Malé and Gan, respectively. The analysis also indicated high rainfall over shorter periods, while the late onset of south west monsoon observed could prolong the drought period. Predictions for 2021 to 2051, from a downscaled model, indicated a slight decrease in rainfall for the south and an increase for the north. For the period of 2081 to 2100 the model predicts an overall increasing trend of rainfall for the whole country. However, the irregularity and uncertainty in monsoonal patterns may lead to severe droughts, as well as flooding due to rainfall (Zahid, 2011).



5. Figure 2.5 Observed changes in rainfall patterns from 1967 to 2011 adapted from the second national Communication (2016)

According to SNC, a daily rainfall of 150 millimetres for the northern region is a 300-year event, while 190mm rainfall event for the central region is a 387-year event. Predictions from SNC showed that, by 2050 to 2100, it is likely that these events will become frequent with a return period of 66 and 23 years, respectively for the north. For the central region, however, the return periods are likely to occur every 140 years by 2050, and every 62 years by 2100 (SNC, 2016). In addition, the north and central regions are also expected to have more droughts, and data from SNC (2016) indicated a rainfall deficit of 4 years for these regions from 1992 to 2102. Additionally, northern and central regions experience approximately a month long consecutive dry period, while it is only half a month in the south. According to these observed data and model predictions, rainfall patterns will change, resulting in more prolonged droughts and frequent recurrence of flooding events.



6. Figure 2.6 Predicted changes in rainfall for 2021 to 2051, and by 2100 for the four zones modelled, adapted from Second National Communication (2016)

2.2.2 Climate change governance and policies in a Maldivian context

The Maldives has been highly vocal for over a quarter of a century in raising the issue of climate change with the international community, and in getting involved in the science, diplomacy, politics, and policies of climate change. Despite this, the global climate change efforts have seldom brought favourable outcomes for SIDS, until the 2015 Paris Agreement. According to this agreement, nations which have highest emissions pledged to emission reduction timelines to curb emissions by 2020. However, policies were not formulated for local levels to address climate change related issues until 2013, when the first Climate Change Policy of Maldives was formulated. For any country, matching their policies to the demands of the time is crucial to prosper in a globalised world (Figueres, 2013). This is even more imperative when the immediate threats of the problem, such as that of climate change, are visible and the country is highly vulnerable with no capacity to adapt. Consequently, climate change has now become the new policy element which determines countries' future stability and prosperity (Figueres, 2013).

In recognising the threats of the climate change impacts, the government of Maldives developed the climate change policy of the Maldives in 2013. The policy was based on the rationalism that climate change is the 21st century's biggest challenge to development and security, affecting every aspect of the Maldivian life and livelihoods. In addition, the Maldives also agreed that the science of climate change is distinct and the threats are real to the viability and existence of the Maldives, as highlighted in the policy document. Hence, the policy postulates that appropriate actions need to be taken to reduce greenhouse gas emissions, to reduce vulnerability, and to build resilience to combat the adverse impacts of climate change. The policy seeks to provide strategic measures for the 10 years from 2014 to 2024 for the implementation, to achieve resilience and safety envisaged for a sustainable and resilient nation.

2.2.3.1 Socio-culture in the Maldives

Most historians and scholars agree that the most prominent change in the socio-cultural history of the Maldives is the conversion of the entire nation to Islam in 1153 AD (Ahmad, 2001; Amir, 2011; Maloney, 1976). According to archaeological evidence, prior to the conversion to Islam, sun worshipping, Hinduism and Buddhism were practiced (Ahmad, 2001). Even though the roots of conversion to Islam are disputed, Maloney (1976) argued that Islam was adopted for politico-economic reasons, such as to reinforce trade with rich Arab merchants, evade the growing powers of Buddhist priests, and minimise external influence from neighbouring Sri Lanka. Maloney (1976) also believed that Islam gave authoritative powers to Sultans over their subjects.

Islam did not only change the people's faith, but also had a major impact on their social norms, customs, and traditions (Amir, 2011). For instance, people were instructed to adhere to various rules and practices, which conflicted with their customs and values, while seclusion of women from society was observed. Nevertheless, the remnants of the highly matriarchal social order and the caste system in existence for centuries assimilated with Islam, modifying Islam to a great extent (Maloney, 1976). For instance, Ibn Battuta (1355) wrote that women were highly liberal, they were allowed to rule and to sit among the Sultan's courtiers, and could often move about in public with the upper parts of their body uncovered (Husain, 1976). Rosset (1886), in his *Text and Graphic* (in Maloney (1976)), found that for most ordinary Maldivians, Islam was a mere act of performing religious duties without deeper understanding of Islamic teachings or the meanings of supplications and prayers. Rosset (1885) and Maloney (1976) also found that strict Islamic Sharia law was never practiced consistently, while during certain periods, the Sultans used Sharia law to oppress people. For instance, Rosset (1885) found that the death penalty was never enforced, while flogging was the most common punishment. Hence, Islam remained as a substratum of the culture and traditions, whilst giving more authority and power to rulers to influence the social order (Amir, 2011; Maloney, 1976).

The second major change in the socio-culture took place in the 1960s, due to modernisation of education, and later on in the 1970s, through the introduction of tourism (Amir, 2011). Prior to the modernisation and westernisation of education, islanders learned rudimentary arithmetic, reading, and writing in the Arabic language, and some basics of performing obligatory religious duties of Islam (Amir, 2011). Until the 1930s, most of the teaching was semiformal due to lack of schools and institutions (Shafeeg, 2000). Additionally, children were also taught skills in fishing, carpentry, or blacksmithing in case of boys, and coir rope making and weaving in case of girls, mainly through participation in these activities. Indeed, the modernised English education system, which began in the 1960s, limited the acquisition of skills needed to adapt within the traditional socio-cultural system of the islands (Amir, 2011).

Introducing the English education system in the Maldives has greatly influenced the socio-culture of islands. In her PhD thesis, *Maldivian Ways of Knowing,* Saeed (2003) argued that the indigenous culture of the Maldives has been greatly impacted by importing the English education system. Saeed (2003) further argued that nearly 90 percent of school leavers fail in achieving the intended results, while becoming "more English than the English", constraining the socio-cultural tenets of the island communities. The modern education system also creates more demand for migration to the capital for better education, causing the demise of creative livelihoods and local living economies in the islands. Consequently, sustainable livelihoods were lost in many islands, and migration to the capital to pursue further education and employment turned into a vicious cycle.

Tourism was introduced to the Maldives in 1972. According to Amir (2011), the initial stage of tourism development was without major planning, allowing nudism and unrestricted mingling of tourists and local communities. Control measures were soon taken, on the behest of Islamic scholars, to protect the island communities from the influence of non-Muslim tourists, mainly from European countries (Amir, 2011). Even though tourism was banned in local inhabited islands until 2009, many people migrated from their islands to work in resort islands, only to return once during each year, or to be permanently relocated in the capital Male'. Amir (2011) believed this migration of young people created a shortage of people to acquire and pass on the essential skills vital for adapting to island life; skills like traditional boat building, weaving, and blacksmithing have been completely lost in several islands in the recent past.

Another major shift in the social order became prominent during the 1990s, and it was caused by the arrival of Maldivian Islamic scholars educated in Pakistan, Saudi Arabia and Egypt (Romero-Frias, 1999). According to Romero-Frias (1999), the Islamic revival movement led by these scholars resulted in "Arabization", causing an increase in the number of veiled women, bearded men, and the inculcation of Middle Eastern culture which conflicted with the local culture, dress codes, and traditions. Romero-Frias (1999) also stated that, the Arabization has led to radicalised views of Islam, causing divisions within the society and loss of traditional cultural values and practices, resulting in significant social impacts. For instance, the creation of religious factions in some islands has caused personal antagonism and animosity between different persons or groups, resulting in negative consequences. Additionally, seclusion and restriction of women from taking part in social events in the absence of a male kin became a norm.

Globalisation has also begun to influence the social culture of Maldivians. For example, the increase in expatriate workers due to globalisation, since the late 1990s, has greatly influenced the economic and social landscape of the Maldivian society (Mohamed, 2014). The expatriate work force increased by 188 percent from 2000-2011, implying a ratio of one worker for every four Maldivians (Mohamed, 2014). According to Mohamed (2014), even though the expatriate workforce enhances economic growth, influx of expatriates leads to local unemployment, especially among youths, resulting in major social issues such as drug abuse and gang violence. Mohamed (2014) also found that the local unemployment rate for youths between the ages of 15-24 was 40 percent in 2010, and it was mostly caused by the influx of expatriate workers into the country. In addition, increased foreign labour also threatens the cultural identity of Maldivians, due to assimilation of foreign norms and values within the society (Mohamed, 2014).

Hence, the major socio-cultural changes in the Maldives have been a consequence of: (a) the conversion to Islam in 1153 AD; (b) modernisation of education and introduction of tourism; (c) Arabization from the 1990s; and (d) globalisation effects and a boom in the expatriate labour force since the 1990s. Such socio-cultural changes can play a major role in the adaptive capacity of small island societies. For instance, the loss of creative livelihoods, traditional kinship, culture and life styles, and increased internal urban migration may lower adaptive capacity of islands.

2.2.3.2 Socio-politics and governance

The Maldives has been a kingdom throughout history, until British influence in the mid-twentieth century resulted in major political transformations. The country was centrally governed as an Islamic Kingdom from 1153 AD until 1968 (Shafeeg, 2000). The king from the nobility ruled with the help of a chief minister, a chief judge, members of the royal family, and ministers. The chief judge, who was widely regarded as the guardian of Islam, was superior to the other courtiers, and was chosen by the king from among Islamic scholars (Nasheed, 1993). A representative of the king was selected from each atoll and each island to collect taxes and to maintain order in the islands. Throughout history, until the 20th century, the government's sole function was to collect tax from the subjects for the privileged ruling elite in Malé (Nasheed, 1993).

Even though Maldives entered the 20th century without any infrastructure and basic facilities for education or health, the isolated islanders were culturally self-sufficient, with minimal contact with the outside world (Shafeeg, 2000). According to O'Shea (2009), based on historical records and writings, Maldivians lived a medieval life of oppression, slavery, and centrally controlled bureaucratic governance until the middle of the 20th century. O'Shea (2009) also found the weakened feudal system of the early 1930s paved the way for the British colonial power to enforce constitutional reforms. The first constitution was ratified in 1932. However, the laws passed by the parliament under the new constitution were beyond the comprehension of ordinary citizens and the frustrated people ousted the constitutional monarch and his cabinet through a revolution in 1933 (Shafeeg, 2000).

The Maldives continued with an elected monarch until 1953. After the 1933 revolution, an aristocrat from the royal family of Malé, who was residing in Egypt at the time, was voted as the new king in absentia (A.H.H Manik, 1999). After being elected as the monarch, Abdul Majeed reformed the British- sponsored constitution and ratified the new constitution in 1934 (A.H.H Manik, 1999). Hence, the Maldives transformed from an absolute monarch to a constitutional monarch, followed by an elected monarch, until the amendment of the constitution in 1953 resulted in the formation of the first republic. Mohamed Amin Didi became the first president of the first republic. The original constitution of 1932 has been reformed again by Amin Didi, and the first major elections were held.

The elected government faced various hardships, including World War Two (WWII). Based on historical records and writings, O'Shea (2009) found that WWII caused a huge famine and starvation throughout the Maldives. However, the plight of islanders was completely ignored by the aristocrats of Malé, who enjoyed a privileged royal life. This led to uprisings in both the north and the south in the early 1940s (O'Shea, 2009). According to historians, nearly half of the population died of starvation and many islanders migrated to other islands to escape from starvation. Several islanders from Gulhi Island died and the rest abandoned their island (A.H.H Manik, 1999). Manik (1999) also found that the food rationing for islanders during WWII was half of that received by Malé people, and the majority of fishing islands starved due to difficulties in exchanging fish for staple foods. The famine and authoritative rule of President

Amin Didi not only resulted in the collapse of the republic, but also cost him his life within a year, and the Maldives reverted back to a constitutional monarchy (A.H.H Manik, 1999).

Though people in other islands had little say in governance, genuine constitutional reforms began under the constitutional monarchy of King Fareed from 1954 (O'Shea, 2009). Affected by the British influence and frustrations, due to negligence by ruling aristocrats from Malé, the three southernmost atolls joined to form a breakaway faction called United Suvadive Islands Republic in March 1959 (Shafeeg, 2000). Meanwhile in Malé, prime minster Ibrahim Nasir organised a referendum to dismantle the breakaway faction in the south, turning it in his favour. Consequently, he led the army from Malé and attacked Thinadhoo Island, the heart and the economic capital of the Suvadive Republic. Many islanders were arrested and tortured, and systematic abuse and rape of islanders occurred (O'Shea, 2009). The islanders were forced to leave the island within 24 hours and were prohibited from returning to their island for six years (Shafeeg, 2000).

In 1965, the Maldives gained full independence from the British, and in 1968 the monarchy was abolished to form the second republic. Ibrahim Nasir, the serving prime minister became the president of the second republic and completed two terms as president. Gayoom was nominated as the second president in 1978, after Nasir decided not to contest for the presidency. Gayoom ruled for 30 years until the first democratic election in 2008 ousted him. With the new constitution of 2008, and the return of democracy, the heavily centralised governance started shifting towards decentralisation.

The government elected under the new constitution of 2008 came with a manifesto and written policies for the first time in the history of the Maldives. The themes of their manifesto were based on good governance, social justice, and economic development. The five key pledges of the new government were to: establish a nationwide transport network; make the living costs affordable to all; provide housing and health care for all; and to combat narcotics abuse and trafficking. This notwithstanding, the government elected in 2008 was ousted in an alleged coup within three years. A new government was elected in 2013, with controversial electoral processes, and the manifesto of the new government was based on economic development. This included developing fisheries, agriculture, and tourism, and increasing job opportunities for youths. In addition, enhancing business opportunities and education for youths was emphasised.

Nearly 60 years after the north and south uprisings, due to the WWII famine and negligence by the central government, power is still centralised within the ruling elitists in the capital Malé. Even though the constitution has been amended fifteen times until now, with the most recent ratification in 2008, the heavily centralised governance of elitism and clientelism continues. According to Benedict (1966), omnipresence and omnipotence of governments is common in small countries. Benedict (1966) believed that smallness of societies in island states results in political elitism dominating in every aspect of community, making the community pervasive to clientelism and overwhelming social dependency. As a case in point, the islanders in the Maldives have minimum authority over governance and ownership of resources. The centrally controlled regulations and economic policies continue to increase disparity in the socio-economic development of islands until now. Consequently, adaptive capacity of islands is greatly influenced by the shaping of the governance system over the years.

2.2.3.3 Socio-economic context

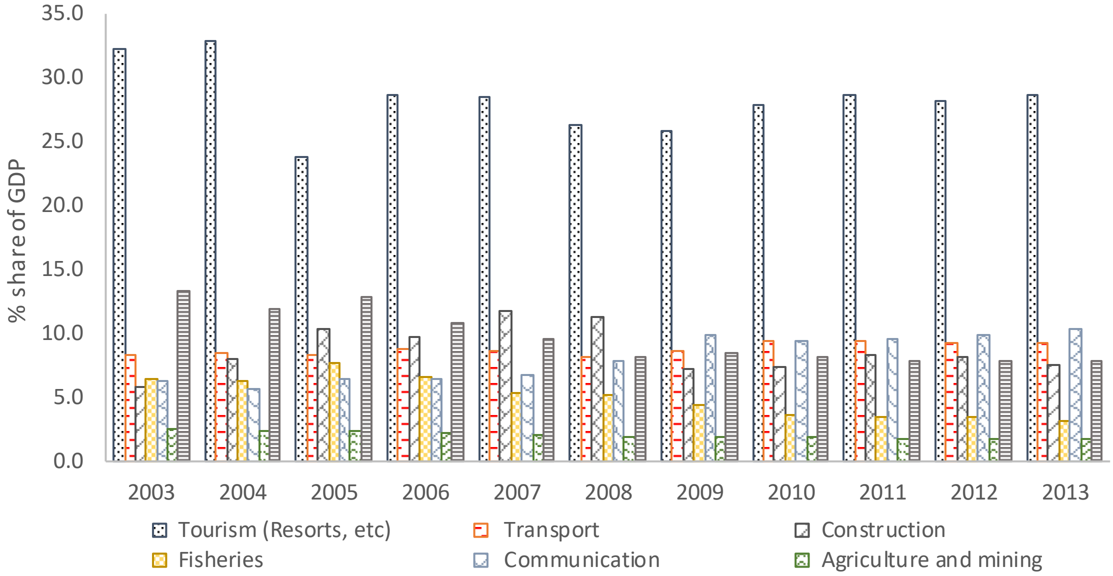
Lack of land-based resources and human capital, as well as a long established feudal system, was a major hurdle for economic development in the Maldives (A.U. Manik, 2012). A.U. Manik (2012) recognised that until the late 1950s and 1960s, the Maldives lacked the essential infrastructure (such as ports, airports, hospitals, schools, harbours, and telecommunication, as well as human resources) vital to venture into the 21st century as a self-sufficient nation. Even though the impact of the industrial revolution in Europe was felt in the Maldives for the first time in 1850, when Indian merchants brought in luxury goods to Malé, people in the outer islands never experienced such luxury (Shafeeg, 2000). In fact, all wealth and education was exclusively for the ruling elites and aristocrats in Malé, and islanders lived a subsistence life isolated from Malé and the rest of the world (A.H.H. Manik, 2000).

In addition to elitism, islanders were also faced with other hardships. A.H.H. Manik (2000) found that only the elites of Malé could travel freely abroad for studies or business, while the rest of the Maldivians had several restrictions. In those days, the islanders were not allowed to export fish, coir rope, or copra without passing through Malé to pay taxes (A.H.H. Manik, 2000); hence, the only foreign trade via sea took several weeks to months, causing hardships for islanders to obtain necessary goods. Until now, Malé was the main port for imports and exports, and the majority of business transactions occurred within the Malé area; today, islanders still face major challenges in trading.

During the period of 1958 to 1978, when Ibrahim Nasir was at the helm of the country (as the prime minister for the first 10 years and then as the president for another 10 years), he pioneered the economic development of the country (A.U. Manik, 2012). According to A.U. Manik (2012), Nasir steered the economy of the Maldives from the poorest in South-East Asia, to one of the richest within a short time span. His economic developments included building infrastructure, such as an international airport, schools, a hospital, a telecommunications facility, and a fish canning factory. He also introduced tourism and shipping, and developed the fishing industry by initiating the mechanisation of the fishing fleet. In addition, education of young people from all over the country through foreign universities became widespread by means of government funded scholarships (A. U. Manik, 2012). Among his other noteworthy economic developments were the establishment of the first national airline, radio and television broadcasting, and establishing a strong shipping company. Hence, Nasir laid the economic foundation of the Maldives.

Maldives had a well-established economic base with a strong currency when President Ibrahim Nasir stepped down in 1978 (A.U. Manik, 2012). Fishing and tourism were developing rapidly and the Maldives enjoyed self-sufficient socio-political independence (A. U. Manik, 2012). After Nasir, during the 30 years of Gayoom's rule, no major economic industries were developed according to Manik (2012). Gayoom focused on education and health and spread modern education throughout the country (ibid). Among his achievements was the improvement of the health and transport sectors. Nevertheless, negligence of social protection and widening of the gap between poor and rich increased at an alarming rate. In 2008, the first democratically elected government began systematic governance with policies and strategies developed based on the needs of the people. Socio-economic wellbeing became a key element of governance with the amendment of the constitution in 2008 and the election that followed.

According to the National Bureau of Statistics (2013), the Maldives has the highest GDP per capita in the South East Asian region, which was US$ 3,846 in 2013. The economy had a steady growth since 2003, with an annual growth of 4 percent from 2003-2013 (National Bureau of Statistics, 2013). The main contributor for GDP was tourism, with a share of 28.2 percent, followed by communication with 9.9 percent, and transport with 9.3 percent, according to 2013 data (Figure 2.1). Even though the country is highly vulnerable to global economic shocks, donor funding and strategic financial planning allows recovery during global financial crisis (SNC, 2016). Moreover, the country still lacks an income tax system, and relies on GST and TGST as the main source of revenue for government.



7. Figure 2.7 Contribution of different sectors to GDP. Adapted from Second National Communication (2016), based on data from National Bureau of Statistics (2013)

2.3 Changing the discourse from vulnerability to adaptive capacity

Small low lying island nations are considered as the most vulnerable to climate change and, for some of them, getting submerged by rising sea levels is considered an imminent threat (Barnett & Campbell, 2010). Most island nations share various constraints related to insularity, such as remoteness, smallness, and peripherality (Kelman, 2014; Royle, 2002). However, defining these terms and applying them in the context of islands is ambiguous (Kelman & West, 2009). For instance, political and economic geography of remote communities in continental land masses are similar to small islands (Royle, 1989). Additionally, heterogeneity of islands makes it impossible to characterise them into a homogenous definition (Hay, 2006); hence, generalising them broadly in relation to their vulnerability, exposure, and adaptive capacity is a major challenge.

Islands face more challenges in the face of global climate change. Barnett and Campbell (2010) argued that remote regions of larger countries share similar vulnerabilities to small islands, in terms of global economic shocks and climate extremes. However, remoteness and isolation exacerbates barriers and limits adaptive capacity in islands, owing to limited resources in health care, education, and transport, where the economies mainly depend on a single sector (Barnett & Campbell, 2010). Barnett and Campbell (2010) also recognised that, compared to remote areas of large countries, climate change poses proportionally greater risks to livelihoods of islanders while intensifying costs for adaptation, in proportion to their GDP. Consequently, vulnerability is considered as the major discourse of climate change on islands, often in association with their existence on Earth (Barnett & Campbell, 2010).

Islands are given similar status to polar bears and penguins to gather international support for greenhouse gas emission reduction (Barnett & Campbell, 2010). Island communities, however, have more capacity to adapt to climate change, despite being undermined by the vulnerability discourse of climate change (Barnett & Campbell, 2010). Additionally, when people perceive a lack of prospects for their islands, they tend to neglect sustainable management of their resources, while hindering potential foreign and local investors (Barnett & Adger, 2003; Barnett & Campbell, 2010). For instance in 2015, when the government of Maldives informed inhabitants of Gaadhoo Island of their resettlement to another island, they stopped the sustainable practices in preserving island vegetation and customary prohibition of turtle harvesting (Visam, 2016). Additionally, the islanders stopped investing in private businesses and infrastructure, meanwhile large trees in the island were cut down and sold (Visam, 2016).

Barnett and Adger (2003) argued that, to avoid similar consequences, a paradigm shift of vulnerability discourse to a language which emphasises risks, adaptation action, adaptive capacity, and uncertainties of climate change, is critical. Hence, a paradigm shift in vulnerability discourse to a language which underpins adaptation is critical for a sustainable future for atoll nations.

In addition to climate change threats, small islands are also faced with challenges of internal urban migration, resource exploitation, corruption, poor governance, pollution, and gender inequities (Kelman & Khan, 2013). However, Kelman and Khan (2013) believed that strengths, such as strong kinships, stronger sense of identity, sustainable livelihood practices, and a wealth of local environmental and social knowledge, exists in small islands. Therefore, the despair of climate change vulnerability of islands needs to shift focus to strengths of island societies, to avoid impeding their adaptability (Barnett & Campbell, 2010). Consequently, understanding the level of adaptive capacity on islands is critical to envisage adaptation actions needed for future sustainability of islands.

2.4 Defining adaptive capacity

Adaptation originated from the natural sciences and evolutionary biology and is broadly defined as the ability of organisms or species to cope to perturbations through genetic and behavioural modification (Smit & Wandel, 2006). The term was first applied to human societies by anthropologist Julian Steward who defined adaptation as ability of human societies to become adapted to environment through subsistence activities (O'Brien & Holland, 1992; Plummer & Armitage, 2010; Smit & Wandel, 2006). Adaptation emerged as a major concept of climate change research in social sciences in the late 1990s (Grothmann & Patt, 2005b). Adaptation research originated from studies on vulnerability and resilience, often with divergent interpretations and characterization, albeit being a key component of both vulnerability and resilience (Engle, 2011).

Adaptation studies were used to understand the most appropriate responses to future climate change until 2001, when the IPCC recognised that a more explanatory variable, adaptive capacity, is essential in the discourse of adaptation (Grothmann & Patt, 2005b). Hence, adaptive capacity became a major concept of adaptation research. In the study of global environmental change, adaptive capacity has been recognised as a function of vulnerability, resilience, sensitivity, and exposure, and is assessed in different temporal and spatial scales in relation to specific disturbances (Smit & Wandel, 2006). Consequently, adaptive capacity has become the major focus in research on climate change adaptation. Adaptive capacity is crucial for the sustainable future of human societies challenged with unprecedented changes, such as climate change (Millenium Ecosystem Assessment, 2005). Impacts related to global warming are widely known to require adaptive capacity to cope. For instance, the global agreement on climate change, signed by world leaders in the 2015 UNFCC COP meeting in Paris, highlighted the critical nature of impacts of warming of the Earth and the urgent need to take measures for adaptation.

Adaptive capacity is a complex, multi-disciplinary concept. Several definitions of adaptive capacity from various disciplines can be found in the literature (Table 2.3). Defining adaptive capacity is crucial to understand the context and contents of the term in a logically, consistent manner, and to make it widely accepted within the discipline of interest (Thywissen, 2006). Thywissen (2006) argued that several definitions of a single term may be developed by different disciplines simultaneously; hence, maintaining uniformity of concepts related to the term is crucial to avoid misconceptions. Definitions developed by different disciplines, in relation to the conceptualisation of adaptive capacity, are based on different contexts. These definitions are valid in their respective disciplines and, therefore, need to be evaluated to develop a suitable homogenous, consistent definition for small islands. Most definitions, given in Table 2.3, refer to the ability of systems or inhabitants to respond and recover from inevitable changes. According to the IPCC (2001, p 879), adaptive capacity is the ability of a system, region or society to adapt to impacts of climate change (Intergovernmental Panel on Climate Change, 2001). Walker (2003) defined adaptive capacity as the ability of both human and non-human actors within a socio-ecological system to cope with new conditions without undermining future options.

The most widely accepted definition of adaptive capacity to climate change is given by the IPCC (2007, p.869), where adaptive capacity is defined as: "*the* ***ability of a system*** *to* ***adjust to climate change*** *(including climate variability and extremes)* ***to moderate potential damages, to take advantage of opportunities****, or* ***to cope with the consequences***" and, hence, is a multidimensional phenomenon (Adger et al., 2007; Intergovernmental Panel on Climate Change, 2001; Nicholls et al., 2007; Plummer & Armitage, 2010). The definition has four thematic concepts: (a) ability of the system; (b) adjusting to climate variability and extremes; (c) moderating or coping with consequences; and (d) taking advantage of opportunities. Each of these concepts has a spatial, temporal, and social element. For instance, the ability of the system depends on the spatial scale of impact, the time of impacts, and social perceptions of ability. Similarly, adjusting to climate variability and extremes depends on the spatial scale of such extremes, the periodicity of such extremes, and the extent of social impact. Likewise, to take advantage of favourable opportunities, the spatial, temporal, and social elements are crucial. Consequently, several independent variables related to spatial, temporal, and social dimensions can influence adaptive capacity.

The concepts, “climate variability and extremes” and “consequences” in the adaptive capacity definition of IPCC also imply a high probability of negative outcomes. In other words, risk is conceptualised where human ability and decision making becomes critical. In addition, the concept of “coping”, in the IPCC (2001) definition, is a function of risk perception, aversion, and prevention, as well as private and public action. Hence, adaptive capacity can be described as the ability of a system to cope with the exposure and risks associated with climate variations and extremes, and involves planning, preparation, and facilitation to implement strategies (Smith & Pilifosova, 2003). In this thesis, adaptive capacity of small islands is defined as the ability of the human and nonhuman actors of the socio-ecological system to adapt to climate variations and extremes, by taking advantage of opportunities to adjust, moderate, and cope with the consequences without undermining future options.

2. Table 2.2 Definitions of adaptive capacity from different disciplines based on different theories and conceptual frameworks, adapted from (Plummer & Armitage, 2010).

No.	Disciplines	Meaning of adaptation	Key concepts	References
1	Natural science/evolutionary biology	Capacity of an organism, species, or ecosystem to develop and change by enhancing fitness through evolution and natural selection.	Capacity of biodiversity, Influenced by evolution	Hamilton (1964), Dawkins (1976), Dobzhansky et al. (1977), Burian (1983), O'Brien and Holland (1992), Dennet (1995), Shanahan (2004)
2	Social sciences (anthropology, geography, sociology)	Capacity of the cultural and institutional setting to cope with change by modulating resources, resulting in the evolution of human society.	Capacity of society Enhanced through social capital	Steward (1968), Braun (1990), O'Brien and Holland (1992), Denevan (1983), Cronk et al. (2000), Stone (2008)
3	Environment and political ecology, resource studies and application	The ability of individuals or society to cope and adapt to disturbances on livelihoods because of vulnerability, exposure, capacity and potential of the society.	Capacity of people Enhanced through economic capital	Chambers and Conway (1992), Sen (1992), Watts and Bohle (1993), Adger and Kelly (1999)
4	Risks and hazards	Managing, coping and adapting to risks and losses to the system because of a hazard. Risks are determined based on hazard characteristics and vulnerability.	Risk aversion and management Enhanced through engineered capital	Burton et al. (1978), Blaikie et al. (1994), Cutter (1996, 2003), Brooks (2003), Dayton-Johnson (2004), Winster et al. (2004), Haque (2005)

No.	Disciplines	Meaning of adaptation	Key concepts	References
5	Climate change studies	Adaptation or adaptability enhanced by modulating the variables which reduce vulnerability: defined as "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with consequences (IPCC 2007, p869).	Adaptability of system, community, and/or region Enhanced by a diversity of variables which reduce vulnerability Moderating and coping and taking advantage of opportunities considered critical	Smithers & Smit (1997), Kelly and Adger (2000), Burton et al. (2002), Smit et al. (2003), O'Brien et al. (2004), Brooks & Adger (2005), Luers (2005), Smit & Wandel (2006) IPCC (2007), Fussel (2007)
6	Resilience thinking and socio-ecological systems	Capacity of the socio-ecological system to manage change and absorb disturbance, across a continuum of dynamic states between sustenance and transformation, through diversity, knowledge, learning, and self-organisation.	Capacity of socio-ecological system To maintain resilient features by shifting system dynamics from a lower to higher adaptive state Enhanced through social and ecological capital	Berkes & Folke (1998), Adger (2000), Gunderson (2000), Gunderson & Holling (2002), Folke et al. (2002) Berkes et al. (2003), Armitage (2005), Folke (2006), Gallopin' (2006), Smit and Wandel (2006), Nelson, et al. (2007), Fazey et al. (2007)

2.5 Determinants of adaptive capacity

Extant literature shows adaptive capacity is influenced by several features or characteristics of a system, and the abilities of its inhabitants. These features or variables are considered as the determinants of adaptive capacity. These determinants include the economic, social, institutional, and technological variables which enhance adaptive capacity to respond to impacts (IPCC, 2001). These determinants interact simultaneously with each other in a dynamic manner, and enhance adaptive capacity through the ability to cope, manage and adjust the system as well as with the availability of resources (Grothmann & Patt, 2005a; Maldonado & Moreno-Sanchez, 2014; Smith & Pilifosova, 2003).

Adaptive capacity reflects availability and ownership of resources, social networking, institutional capacity, governance and technology (Adger et al., 2007). These determinants vary spatially, temporally, and socially, providing advantages as well as disadvantages in adjusting, moderating, and coping with climate extremes and in utilising opportunities (Smith & Pilifosova, 2003). Consequently, several studies on adaptive capacity assessments focus on the crucial indicators of a system’s ability, such as efficiency of institutions, governance, and management (Engle, 2011; Engle & Lemos, 2010; Gupta et al., 2010; Johnston & Hesseln, 2012; McClanahan & Cinner, 2011; Yohe & Tol, 2002). However, emphasis is also given to socio-cognitive perceptions on subjective and objective capacity (Grothmann & Patt, 2005b). Therefore, determinants of adaptive capacity include a diversity of dependent variables or features which influence adaptive capacity.

Socio-cognitive factors of adaptation tend to be overlooked in the adaptive capacity assessments, though new evidence shows that motivation and perceived abilities of people are crucial in determining their adaptive capacity (Grothmann & Patt, 2005a). Hence, to advance adaptive capacity to an operational level, determinants must be explored in relation to how individuals, communities or populations perceive adaptive capacity (Grothmann & Patt, 2005b). In addition, human perception is also crucial to make adaptive capacity meaningful, as perceptions can enhance or inhibit adaptive capacity (Bohensky, Stone-Jovicich, Larson, & Marshall, 2010). Adaptive capacity is also a positive attribute which can be modulated by humans, affecting both social and ecological systems (Engle, 2011). Thus, it is crucial to assess the policies, management, governance and institutions of socio-ecological systems that influence adaptation to future climate change impacts (Adger, Hughes, Folke, Carpenter, & Rockström, 2005; Engle, 2011; Engle & Lemos, 2010). To understand the adaptive capacity of small islands, several determinants related to biophysical elements, socio-economics, governance, and management, as well as resource availability and utilisation, need to be assessed. In this thesis, critical variables of the social and natural environment of the islands, which influence adaptive capacity, will be evaluated and assessed.

2.6 Theorising and framing adaptive capacity

2.6.1 Theoretical Orientation of research

Theorising in research involves linking the research to theory to produce an overarching theoretical orientation (Ritzer, 1990). The ontology or philosophy of being, or existence of knowledge, relates to the research paradigms or philosophical worldviews applied in research design (Creswell, 2014). Research paradigms provide guidance for the researcher, through different epistemological worldviews, to establish the philosophical context of the research (Bak, 2011). According to Creswell (2014), paradigms include post positivism, constructivism, pragmatism, and transformative worldviews. While positivist reductionism relies on objective observation to derive statistical correlations, it could undermine the context and meanings of subjective knowledge developed from experiential learning (Bak, 2011). On the contrary, the constructivists view the world as a social construct of knowledge, with subjective and meaningful experiences gained from the world (Bak, 2011), by exploration and interpretation of knowledge (Creswell, 2014). Hence, a research paradigm must be chosen based on the context and setting of research problem to establish the philosophical context.

In understanding complex phenomena, pragmatism is well recognised as a worldview, whereby knowledge is both a social construct and a reality of meaningful experiences of the world (Bak, 2011). Pragmatism integrates both subjective and objective epistemological positions to explore the truth that works in solving the research problem, through observations, lived experiences, and experiments (Bak, 2011; Teddlie & Tashakkori, 2009). In this view, the world is regarded as a complex, dynamic, value-oriented system, where social justice and political aims are incorporated (Creswell, 2014). Pragmatism provides a window to different worldviews, methodologies and assumptions, as well as different methods of data collection and systematic approaches (Creswell, 2014). Hence, pragmatism provides the epistemological justification and logic for mixing different research methodologies and approaches (Johnson, Onwuegbuzie, & Turner, 2007). Therefore, in formulating a research methodology for a complex multidisciplinary subject, such as adaptive capacity, a pragmatist worldview can be used to establish the philosophical context of the research. Thus, the research methodology in this thesis is formulated with the basis of pragmatist worldview.

In developing research methodologies and determining hypotheses based on a pragmatist worldview, logical reasoning is required (Creswell, 2014). Dunlap and Catton (1994) argued that all human knowledge, including the phenomena of Global Environmental Change (GEC), is socially constructed knowledge leading to a form of social reductionism, varying in validity and credibility. Hence, to understand the human dimension of GEC, macro and micro level cause and effect relationships of global climate change within a system must be hypothesised (Dunlap & Catton, 1994). Consequently, developing comprehensive methodologies to study concepts related to global environmental change is a huge challenge for social and environmental scientists (Dunlap & Catton, 1994). Dunlap and Catton (1994) argued that the metatheoretical challenge in GEC studies is the limited understanding of cause and effect relationships between biophysical phenomena, and how humans perceive such phenomena. Consequently, hypothesising and interpreting causal linkages of physical impacts and attitudes and beliefs of adaptive capacity is complex.

Divergence of biophysical and psychosocial elements in climate change studies arose due to human exceptionalism widely popular before the 1980s, where humans were considered as an exception to ecological and environmental change (Dunlap & Catton, 1994). However, the New Ecological Paradigm (NEP) developed by Catton and Dunlap (1994) emphasises the human dimension of environmental change linking with the biophysical and social elements (Dunlap & Catton, 1994). Hence, the human dimension has become an integral part of GEC (Dunlap & Jones, 2001). Consequently, to understand complex interlinkages of human and natural systems in GEC, comprehensive theoretical frameworks underpinning both social and ecological aspects need to be developed.

The interdependencies of environment and humans are complex. According to Dietz and Rosa (2001), such complexities and interdependencies require a hierarchy of knowledge based on ecological changes. Dietz and Rosa (2001) further argued that a systematic normative theory must be developed to understand the discourse of complexities of GEC. Consequently, socio-ecological research on GEC requires integration of different theories, even though the wider scientific community regards GEC as an ontological state of the world (Dietz & Rosa, 2001). Therefore, any adaptive capacity framework must integrate ontological realism with epistemology of constructivism (Buttel & Humphrey, 2001; Dietz & Rosa, 2001). Climate change impacts on Maldivian islands are real and adaptive capacity of Maldivian islands may differ. Hence, a realist ontology and an objectivist epistemology are inherent in answering the main research question of adaptive capacity of islands of the Maldives to climate change. However, climate change impacts and adaptive capacity also could be a social construct varying across contexts and time. Hence, a relativist ontology and a constructivist epistemology can also provide the empirical reality of the research problem.

Adaptive capacity is a multi-disciplinary concept. According to Williamson et al. (2012), adaptive capacity variables evolved from the disciplines of economics, sociology, psychology, political science, law, and human geography. Thus, adaptive capacity assessments must be examined through an integrated multi-disciplinary methodology, with an understanding of various theoretical dimensions. Studies on adaptive capacity show diverse theoretical foundations. Adaptive capacity has been framed in various theories based on socio-ecological systems, socio-economics, and sustainable development perspectives. In most literature, risk-based theoretical models utilising both social construction and representation of reality are applied in adaptive capacity theories (Renn & Klinke, 2001). Additionally, social and economic theories are used, as adaptive capacity is a function of wealth and resources available, both as natural capital and social capital at macro and micro levels (Adger, 2003). On the other hand, psycho-social theories related to motivation of humans and their private actions, such as, values, preferences and beliefs, are used in adaptive capacity assessments (Grothmann & Patt, 2005b). Hence, theorising adaptive capacity from diverse orientations and perspectives is essential to fathom out the results of research in relation to various theories.

Theoretical framing utilised to investigate adaptive capacity in this research will be described in the following sections. Integration of various theoretical perspectives from physical, socio-economic, and psycho-social dimensions of adaptive capacity will be described in detail in the following sections. Theories on islandness, protection motivation theory, and theory of reasoned action and economic theories are discussed in the sections below.

2.6.1.1 Theorizing adaptive capacity from Islandness

Small islands are an integral part of human civilisation. In island studies, a major area of contention is whether islands are vulnerable or resilient (Hay, 2006). Hay (2006) found that while many scholars argue about how boundedness, remoteness, and isolation influence the adaptive capacity of islands, others contend islands as insignificant backwaters. Hay (2006) argued that a strong sense of identity in islanders arose due to being bounded by water and such an identity acts as a source of resilience and versatility in islanders. Hay (2006) also recognised that for the construction of a coherent theory to study islands, the phenomenon of "place" and "theories of place" must be incorporated. Hay (2006) argued that place is an endowment of how people collectively shape a bounded space through institutions, social capital, and communal activities. Hence, theories of place must be applied in adaptive capacity of islands.

Islandness is regarded as a "sense of being in place" (Stratford, 2008), or as a "visceral experience" (Vannini & Taggart, 2013). In this thesis, islandness will be theorised based on the perspective of Vannini and Taggart (2013). The theoretical perspective of islandness, developed by Vannini and Taggart (2013), based on the theoretical orientation of non-representational dwellings perspective of Ingold (2000), is regarded as a system of relationships underpinned by an array of sensory engagements of islanders with their environment. Non-representational dwellings perspective is an integration of both non-representational theory and the dwellings perspective.

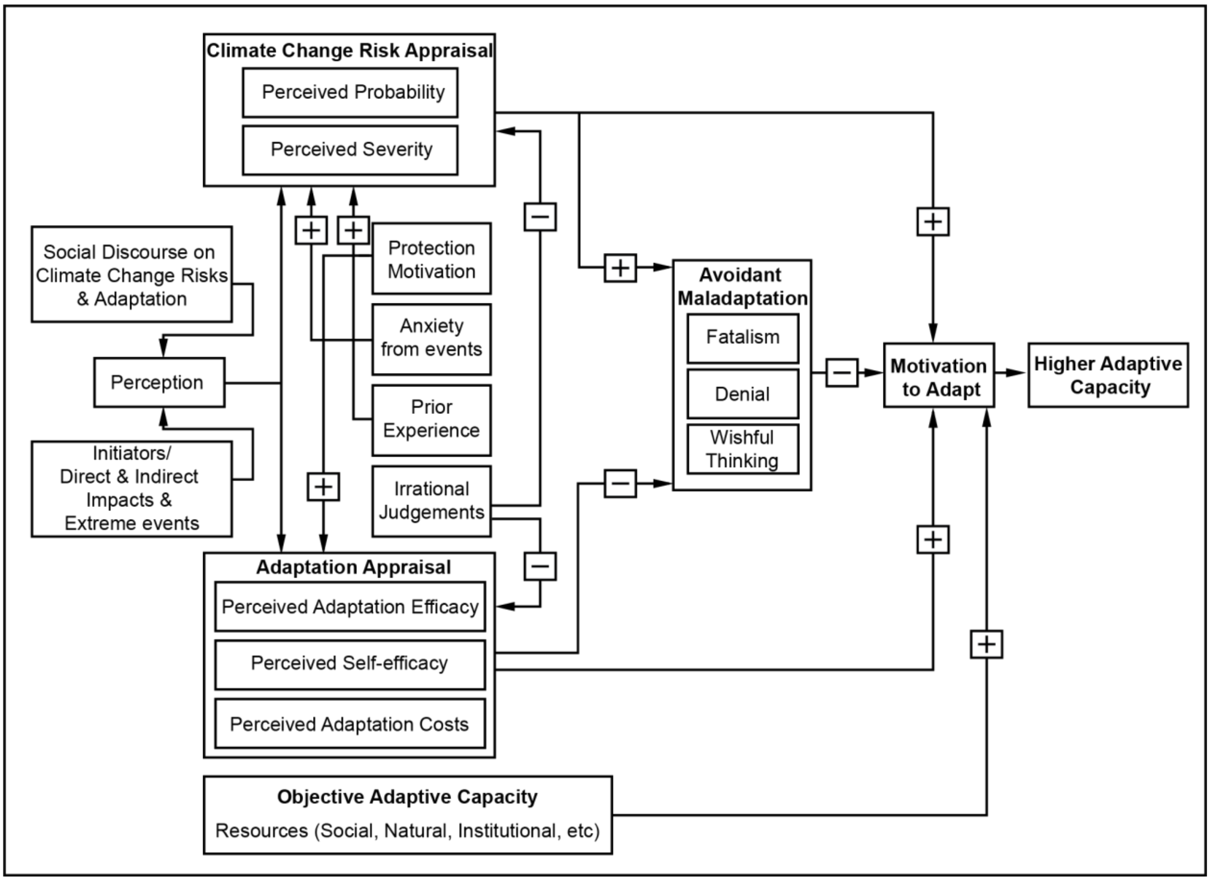
Non-representational theory emerged from post-structuralism, as an amalgamation of diverse perspectives including post phenomenology and pragmatism (Vannini & Taggart, 2013). Non-representational theory is described by certain premises, according to Thrift (2008) and as agreed by Vannini (2011), of which reflexivity and practicality of knowledge, and the spatial imagery, are critical. Non-representational theory aims to capture the flow of movements in the concurrent setting based on "events, relations, practices and performances, affects and backgrounds" (Vannini, 2011, p. 9). Dwelling, as a noun, refers to a particular place of inhabitancy, and as a verb, refers to a process of making sense of place and living within the dynamics of a place (Vannini, 2011). Hence, dwelling is a process "emergent, contextual, lived, practiced, and only static in space or time in the most facile of sense" (Vannini, Waskul, Gottschalk, & Ellis-Newstead, 2012, p. 364). Vannini and Taggart (2013) also argued that islands must be studied and comprehended based on the lived experiences and practices of islanders. According to "active perceptual engagement", islandness is shaped by the way islanders dwell on their island (Ingold, 2000). In conclusion, islandness can be regarded as: "... *the shape taken by how you* [islanders] *dwell on your island, by the ways you have become socialized to understand and appreciate its sounds, sights, textures, flavors, and scents, by the ways inhabitants' sensibilities may differ from others,' by the lessons and intuitions they have acquired in adapting to their place, by their orientations to movement, rest, and encounter, their speeds, and rhythms*." (Vannini & Taggart, 2013, p. 236).

A major aspect of islandness, within a non-representational dwellings perspective, is the dynamic nature of islands and influence of social capital on adaptive capacity. The notion that social capital can have a great influence on adaptive capacity is broadly accepted in social sciences (Adger, 2010). Social capital refers to relationships, within community members, for taking collective actions, and is viewed as an important determinant of adaptive capacity (Williamson et al., 2012). Thus, relationships within the island community can enhance adaptive capacity through collective action. Islandness encompasses strong kinship, and social bonding and linking, which plays a crucial part in island life and can greatly influence adaptive capacity.

Theory of islandness, from a non-representational dwellings perspective, can be integrated with adaptive capacity of islands through the relationship between place and intuitive engagement of islanders with their environment. Additionally, the social bonding and linking and kinship ties can also be conceptualised within islandness, to understand the adaptive capacity of islanders. Moreover, the strong sense of place that islanders postulate with their islands can only be theorised from islandness. In this thesis, adaptive capacity of islands will be framed based on the non-representational dwellings perspective of islandness.

2.6.1.2 Theorizing adaptive capacity from a socio-psychological model

Developing a theory of adaptive capacity based on decision making processes is essential to understand the adaptive behaviour of people (Grothmann & Patt, 2005a). Grothmann and Patt believed that such a theoretical perspective can be developed from psychology and behavioural economics. They argued that perceived behavioural choices should be considered, since perceived adaptive capacity determines adaptation actions of people. On the other hand, the motivation for adaptation action is based on relative risk perception (Grothmann & Patt, 2005a). According to Grothmann and Patt (2005a), motivation and risk perception are based on expectancy value theories and the Protection Motivation Theory (PMT) by Rogers (1983), and Rogers and Prentice-Dunn (1997). Grothmann and Patt (ibid) developed a model to study adaptive capacity using the PMT model. In their model, the two critical processes of *"threat appraisal"* and *"coping appraisal"* are evaluated as distinct characteristics. Threat appraisal is based on the probability of losing what a person values, as a result of not taking any actions, or not changing behaviour. Coping appraisal is based on ability to cope and prevent any loss from a threat, and the ability to pay to cope (Figure 2.8).



8. Figure 2.8 Socio-cognitive model of proactive private adaptation to climate change impacts Source: adapted from Grothmann and Patt (2005a) with information from Reser and Swim (2011)

In this model, the two components of "Risk Perception" are perceived probability and perceived severity. As agreed by Grothmann and Patt (2005a), probability is a more suitable term for adaptive capacity as it characterises risk. Perceived probability is, thus, based on how people perceive level of exposure to a threat. For instance, how flooding due to increased rain may damage household goods. On the other hand, perceived severity is based on the degree of loss to the property due to a threat, such as a flood. According to the model, adaptive capacity perception is secondary to risk perception and is initiated when a given threshold of threat appraisal is reached (Grothmann and Patt, 2005a). Adaptive capacity perception is, therefore, based on behaviour. Grothmann and Patt (2005a) also believed behavioural actions in such circumstances can be understood by the Theory of Reasoned Action (TRA).

TRA, developed by Ajzen and Fishbein (1980), explains how beliefs, attitudes, and intentions are linked to behavioural actions of humans, such as in preventing flood damage to household goods. Hence, "perceived adaptation efficacy" in the model is based on the beliefs of people that their actions will give a positive result in preventing climate change threats. "Perceived self-efficacy" is based on the perceived ability to take necessary actions in the face of climate change threats; for instance, the ability to pay for costs to raise the floor of the house. The element in "perceived adaptation costs" refers to expected costs to take actions to respond to threats.

According to the TRA model of Ajzen and Fishbein (1980), perceived adaptive capacity leads to actions which can cause adaptive or maladaptive responses. Adaptive responses enhance adaptive capacity, while maladaptive responses lower adaptive capacity. Maladaptive responses include denial of climate change, wishful thinking, and fatalism. This aspect is critical in this study as people living in highly vulnerable islands may exhibit maladaptive responses as a strategy to cope with negative emotional consequences, as agreed by Grothmann and Patt (2005a). They argued that such behaviour, while it protects psychological wellbeing, does not necessarily enhance adaptive capacity, as it does not prevent loss and damage from impacts (Grothmann & Patt, 2005a).

The "maladaptation" component of the model is based on adaptive actions. As explained by TRA, the adaptation intention is based on beliefs, attitudes and ability. Grothmann and Patt (ibid) argued that lack of objective adaptive capacity will prevent people from taking necessary actions, even though they may have an intention to act. This is where the role of adaptive capacity indicators can become crucial. For instance, poorer and marginalised countries are more sensitive and have higher exposure to climate change impacts (Tol, 2015). Hence, those countries have lower adaptive capacity, resulting from lack of finance, technology, and political will (Adger, 2003; Tol, 2015; Yohe & Tol, 2002).

The PMT model was used to study adaptive capacity in different contexts. For instance, Grothmann and Reusswig (2006) used this model to study why some people take precautionary action against flooding in Germany. Grothmann and Reusswig (2006) collected data on residents' private actions for flood prevention based on:

- perceptions of previous flood events;
- perceptions of risks of future floods;
- reliability of public strategies to protect from floods;
- efficacy and costs for private actions;
- perceptions on ability to take private actions; and
- non-protective actions, such as wishful thinking.

Quantitative telephone surveys and regression analysis were used to compare various socio-economic indicators against how people responded. This study showed that actions of people to threat of flood can be predicted more efficiently using this model, instead of an assessment of socio-economic indicators. The results also indicated net household income is not significant in adaptive capacity, contrary to the belief that income, wealth, and resources are the major determinants of adaptive capacity. In a different case study, by Grothmann and Reusswig (2006) on proactive adaptation of Zimbabwean farmers to drought, it was found that when people perceive lack of adaptive capacity or ability to act, their intentions to respond to droughts becomes lower. Using the PMT model to study adaptation actions of farmers in Sri Lanka, Truelove, Carrico, and Thabrew (2015) found the PMT model is more robust in predicting adaptive behaviour and actions than a demographic model. The study also found that perceived ability is critical to enhance adaptive capacity of farmers.

According to the PMT model and TRA, people's adaptive capacity is based on how they perceive threats and their objective and subjective coping capacity. Hence, in studying the adaptive capacity of islands, perceptions can be captured and theorised based on this model. The model can determine how people will respond to future climate threats based on their perceptions on threats and their abilities. Hence, this model will be crucial in determining adaptive capacity of islands to climate change.

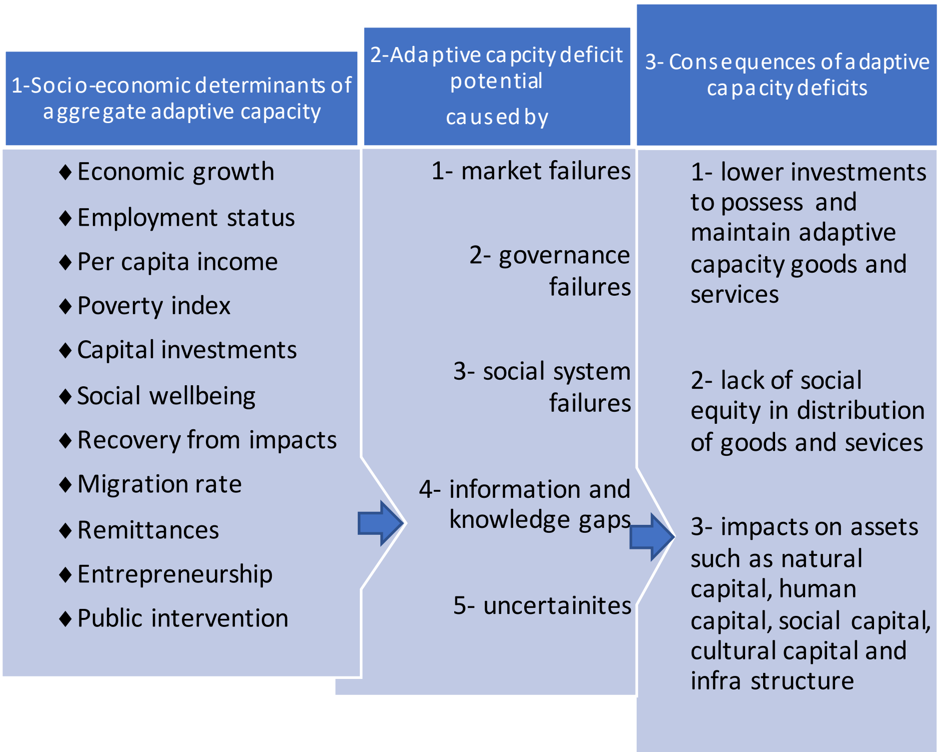
2.6.1.3 Adaptive capacity and socio-economic theories

Economic theories have an immense potential to provide integrated frameworks to evaluate adaptive capacity (Williamson et al., 2012). Williamson et al. (2012) has given a comprehensive theorisation to spell out and analyse adaptive capacity. Hence, the account given by Williamson et al. (2012) is utilised to explore adaptive capacity from an economic theory perspective. Adaptive capacity in human systems varies due to requirement (demand), supply (cost), and income (revenue) and these variations, restrict verifying the susceptibility of the system to climate change by determining a system as high or low in adaptive capacity (Williamson et al., 2012). Hence, to understand causal linkages, adaptive capacity deficits, the causes of these deficits, and their consequences, have to be assessed (Williamson et al., 2012). According to Williamson et al. (2012), adaptive capacity is lowered due to irrational choices by people, as well as economic and governance failures, leading to deficits such as inequity, economic inefficiency, and reduced efficacy of people.

The consequences of climate change for local economies can also provide an understanding of adaptive capacity. According to Williamson et al. (2012), local economies are adversely affected by climate change. Hence, the existing capacity of the economy, as well as the response of the economy to impacts, can be evaluated to assess adaptive capacity. Williamson and others argue that features of economies which influence adaptive capacity such as public interest in markets, efficiency of markets, economic diversity and available technologies and their applications in terms of scale, flexibility and substitutes are often neglected in general and community based adaptive capacity assessments. Consequently, the use of economic theories is critical to gain an insight into adaptive capacity, based on the economic impacts of climate change.

Adaptive capacity thresholds are complex, and assessment is challenging. However, by assessing aggregate adaptive capacity of the system, based on motivation for possessing, purchasing, and enhancing adaptive capacity, as well as ability to pay, can provide thresholds of adaptive capacity (Williamson et al., 2012). These factors are related to the basic economic theories of demand and utility. The motivation to possess and purchase, as well as ability to pay, creates demand for adaptive capacity goods and services. In addition, people will pay for goods and services which provide them higher utilities and, thus, this demand is based on the utility function. Therefore, utility theory is critical for understanding adaptive capacity. Williamson et al. (2012), believed the adaptive capacity goods or services purchased and possessed is determined by choices influenced by "*rules, norms, standards, policies, regulations, institutions, markets, customs, prices, costs, and incomes*" (p 50). Hence, when people make rational choices and have efficient systems conducive for private investments, their adaptive capacity will become optimal (Williamson et al., 2012).

Adaptive capacity also has the characteristics of a public good (Williamson et al., 2012). Williamson et al. (2012) believed that to maximise welfare of any public good, marginal benefit must be equal to marginal cost for all goods, and the welfare maximising level is determined by people. Therefore, to reach a socially favourable level of adaptive capacity, markets and institutions must be efficient, and both producers and consumers must make well informed rational choices. Williamson et al. (2012) also argue that the investment choice for adaptive capacity is influenced by the scale, remoteness, and natural resources of the system. According to Williamson et al. (2012), the factors which limit adaptive capacity include: failures in market; governance; institutions; social systems and knowledge; and information gaps and uncertainties. Hence, these factors will contribute to lower investments in adaptive capacity, resulting in major consequences for enhancing adaptive capacity. An economic model of adaptive capacity assessment involves three major stages, as demonstrated in Figure 2.9, based on Williamson et al. (2012).



9. Figure 2.9 Economic Model of Adaptive Capacity, adapted from Williamson et al. (2012)

Theorisation of adaptive capacity, based on demand and utility theory, is useful to understand the response of people. In addition, the economic theories can also help to aggregate socio-economic factors influencing adaptive capacity into an index. The theory can also provide an understanding of the causes of adaptive capacities from socio-economic factors, as well as consequences of these deficits on future adaptive capacity of islands. Hence, elements from economic theories will be critical in formulating an adaptive capacity index for islands.

2.6.2 Framing of adaptive capacity

Research frameworks are developed in order to provide "assumptions, concepts, values and practices" which encompass the reality of the research problem (Schlüter, Hinkel, Bots, & Arlinghaus, 2014). Designing frameworks with robust methodologies, specific to the context and relevant to decision makers, is a major challenge in adaptive capacity assessments (Binder, Hinkel, Bots, & Pahl-Wostl, 2013). There are several frameworks of adaptive capacity and major studies which utilise indicator-based frameworks. Engle (2011) argued that such frameworks seldom fit within the context and are too rigid and top-down to illustrate the dynamism of adaptive capacity. Therefore, multiple frameworks of adaptive capacity must be explored to determine suitable assessment methods.

Adaptive capacity assessments began with the Third Assessment Report of the IPCC (2001), and were mostly focused on national and sub-national levels, with both a general approach and a community approach by measuring determinants (Williamson et al., 2012). The conceptual underpinnings for these assessments were based on social and economic indicators and included multiple frameworks and methodologies (Adger & Vincent, 2005; Bohensky et al., 2010; Nelson et al., 2010). This included vulnerability frameworks (Smit & Pilifosova, 2003; Yohe & Tol, 2002), resilience frameworks (Berkes, Colding, & Folke, 2003; Folke, 2006; Folke et al., 2002), and more recently, the rural livelihoods framework (Goulden, Adger, Allison, & Conway, 2013; McClanahan & Cinner, 2011; Nelson et al., 2010), as well as systems approaches (Espinosa & Walker, 2011), and Participatory Climate Change Adaptation Appraisals (PCCAA) (Moser & Stein, 2011). Meanwhile, economic frameworks (Williamson et al., 2012), and historical case studies of past civilisations, are also becoming useful in adaptive capacity assessments (Bussey et al., 2012). For instance, case studies on collapse of past civilisations, armed with sophisticated, complex, and creative structures and functions, were studied to understand various socio-ecological deficits behind their collapse as analogues of present systems (Motesharrei, Rivas, & Kalnay, 2014). Hence, a diversity of frameworks has been established by multiple disciplines to study adaptive capacity.

Adaptive capacity varies depending on the structure and functionality of the system and the type of disturbance faced (Adger & Vincent, 2005). Hence, major themes commonly used in conceptual frameworks of adaptive capacity are based on vulnerability, adaptation, and resilience theories (Bohensky et al., 2010). Additionally, all conceptual and theoretical models of adaptive capacity are based on the context, the scale, and how knowledge and information is perceived and applied (Bohensky et al., 2010).

According to extant literature, adaptive capacity assessments involve integration of different theories and frameworks. Therefore, an interdisciplinary approach can be utilised to understand adaptive capacity of islands. Szostak (2013) recognised that the interdisciplinary approach is an evolving disciplinary perspective utilised to generate a comprehensive and nuanced understanding of a research problem. Additionally, interdisciplinary research integrates multiple theories and methods, while recognising that all theories, methods and disciplines have different strengths and advantages (Pujadas, Garvin, & Szostak, 2013). Consequently, the latent nature of adaptive capacity and its complexities requires an integrated conceptual framework. The conceptual framework developed for this thesis will be described in the next chapter (Chapter III, Methodology) of this thesis.

2.6.2.1 Framing from resilience perspective

Resilience emerged as an ecological concept in the 1970s, and was used to understand how ecosystems maintain stability during disturbances (Berkes et al., 2003). Adaptive capacity has been conceptualised using the resilient theory of socio-ecological systems by Folke (2006), drawing on concepts developed by Holling (1973). The resilience perspective, which emerged from observations of predator prey relationships, illustrates that ecological systems comprise a multitude of stable realms interacting with ecological processes, disturbances, and diversity, in various temporal and spatial scales (Folke, 2006). Hence, the resilient approach underpins the capacity of the system to persist to change through continuous evolution and shifting towards a more desirable state through innovation (Folke, 2006). Therefore, the system is more dynamic in nature and often regarded as in "alternate configurations of states", as the prospective of a single stable state functioning in the same manner is unlikely (Walker, 2003). In shifting from ecological perspective, Folke et al. (2002) distinguished ecological resilience from engineered resilience with regard to the ability to resist perturbations. Consequently, adaptive capacity of the system determines the disturbance the system can undergo while retaining structure and functioning without shifting to a diverged *modus operandi* (Gunderson, 2003).

In resilience literature, adaptive capacity is framed within both the social and ecological domains and, therefore, emphasises the system dynamics (Walker et al., 2006). Thus, the resilient approach is studied under the broad umbrella of the socio-ecological system context, which encompasses social resilience and ecological resilience (Adger, 2000). Resilience frameworks on adaptive capacity have been criticised for the heavy emphasis on ecological principles (Cote & Nightingale, 2012). Cote and Nightingale (ibid) argued that this emphasis limits defining what constitutes a desirable system and for whom, and they believe the premise of "resilience of what?" and "for whom?" is seldom in the focus of resilience framing. Cote and Nightingale (ibid) also believed that limitations in determining the scale can arise when resilience is framed within socio-ecological system, as certain characteristics of systems and other critical processes of change within them may become obscured. Hence, the approach must encompass the limits and boundaries of socio-ecological systems.

2.6.2.2 Framing based on socio-ecological systems (SES)

The systems approach, utilised in adaptive capacity assessments, focuses on systems and people in their entirety. A systems approach involves understanding how the system behaves due to interactions within the system; from the way resources flow and revolve within the system (Pickett, Burch Jr, & Grove, 1999). In this approach, emphasis is given on human and environment systems, including feedback systems and perceptions, as well as social cognition (Newell et al., 2005). Such systems are referred to as socio-ecological systems. These dynamic systems are limited and shaped by their socio-ecological context, and they coevolve through the interactions between actors, institutions, and resources within the system (Holling & Gunderson, 2002). These coevolving dynamics can have major influences on adaptive capacity of the system to climate change and, therefore, SES is a significant framework for adaptive capacity.

In applying a SES perspective, the natural world is visualised as "networks of living systems each composed of smaller systems and nested with in other living systems" (p. 7), forming a complex organisation (Espinosa & Walker, 2011). According to Espinosa and Walker (2011), by appreciating human activities and institutions as assemblages of "self-organising systems nested within one another, co-evolving within each other and their environment" (p. 29), it is more likely that the adaptability and sustainability of a society will be understood. Hence, the SES approach can provide a better understanding of interactions of the dynamics which drive adaptive capacity.

2.6.2.3 Framing based on vulnerability

Adaptive capacity assessments also use vulnerability frameworks. In this approach, a lack of adaptive capacity is directly correlated as a causation of vulnerability (Eakin & Luers, 2006). According to Eakin and Luers (2006), such an approach can identify the areas that must be focussed on to reduce vulnerability and to enhance adaptation or adaptive capacity. In linking adaptive capacity to vulnerability, the IPCC coined exposure and sensitivity (Adger et al., 2007; Engle, 2011; Smit & Wandel, 2006). Intergovernmental Panel on Climate Change (2012) defined exposure as proneness of an area to climate change, with people, their livelihoods, and other endowments, while sensitivity is referred to as susceptibility to harm. Hence, in the vulnerability approach, adaptive capacity has been evaluated as a positive attribute of the system, whereby high vulnerability reduces adaptive capacity vis-à-vis (Engle, 2011).

Critics of vulnerability approach have identified that use of macro scale indices in vulnerability frameworks often does not represent the dynamism of systems (Park, Howden, & Crimp, 2012). Other arguments against vulnerability include the arbitrariness of conclusions from indices, due limitations in weighting and "incommensurability" of data (Park et al., 2012). Hence, Park et al. (2012), suggested applying system-based perspectives, where multiple drivers of social, economic, and environmental adaptive capacity, and vulnerability, can be integrated.

2.6.2.4 Framing based on political ecology

Environmental issues and capacity to adapt are framed in political ecology, since the political and economic contexts are inseparable from adaptive capacity (Escobar, 1998). Literature on adaptive capacity shows that adaptive capacity determinants are closely related to politics, governance, and resources, making it mutually inclusive within a political ecology frame. Hence, adaptive capacity is framed socially and politically, with regard to vulnerability, as a dialectic relationship between ecology, political economy, social traditions, and individual agency (Ajibade & McBean, 2014; Blaikie, 1995; Pelling & High, 2005). Political ecology is, therefore, critical to understanding how external influences affect adaptive capacity of islands.

2.6.2.5 Framing based on sustainable livelihoods approach

The Sustainable livelihood approach has gained momentum in adaptive capacity research in recent years. Livelihood approaches regard the aspects of poverty, vulnerability, and marginalisation through the lived experiences of people (Nyamwanza, 2012). Thus, a livelihood approach focuses on the context in which people live, such as socio-economic, political, and demographic contexts, as well as their access to natural, human, physical, social, and financial resources: how institutions and policies govern utilisation of resources as well as priorities and issues faced by people (Ashley & Carney, 1999). Consequently, the livelihood approach is integral to understand adaptive capacity to climate change as livelihood characterises determinants of adaptive capacity.

Application of sustainable livelihood framework as an analytical tool in adaptive capacity assessment will help to identify how adaptive capacity is enhanced from the assets and resources available, and the potential conversion of these assets for livelihood outcomes (Park et al., 2012). Additionally, livelihood frameworks can accommodate multi-dimensional and multi-scale issues of climate change, even though small sample sizes in such studies results in biased interpretations (Park et al., 2012). Furthermore, indicators of livelihood resilience and adaptive capacity are indistinguishable and, thus, can be inferred indirectly from livelihood systems (Nyamwanza, 2012). Hence, sustainable livelihood frameworks can be used in the study of adaptive capacity of islands, with careful selection of participants and indicators.

2.7 Synthesis of different frameworks used to study adaptive capacity

To assess adaptive capacity at a community level, the IPCC Fourth Assessment Report (2007) provided detailed determinants (economic, social, and technological, etc.), and how these determinants influence the improvement of adaptive capacity. The advantage of assessing adaptive capacity at a community level lies in the understanding of the role of social processes and systems in enhancing adaptive capacity, albeit with adaptive capacity being inherent and latent in nature with intangible attributes (Williamson et al., 2012). Williamson et al. (2012) argued that the determinants used in the IPCC general adaptive capacity assessments are too broad, making it difficult to determine the specific influence of a given determinant on a given location. Hence, the community adaptive capacity assessment method has major limitations in the evaluation of adaptive capacity of islands.

Most assessments on adaptive capacity have separated adaptive capacity into either a resilience framework or a vulnerability framework in conceptual and methodological approaches (Engle, 2011). Engle (2011) argued that adaptive capacity is an attribute that must be integrated with resilience and vulnerability for more comprehensive adaptive capacity assessments. Vulnerability framing focuses more on the actors while resilience framing focuses more on the socio-ecological system. However, a system-based focus leads to more quantitative approaches, as system characteristics are assessed from quantitative indices (Engle, 2011). Hence, to understand adaptive capacity of both the system and the actors, vulnerability and resilience must be integrated (Engle, 2011).

Comprehensive assessments of adaptive capacity are also challenged with quantifying adaptive capacity and lack of robust assessment methods (Engle, 2011). According to Engle (2011), in most studies, adaptive capacity assessments are carried out by empirical observation of the impacts from past extreme events as analogues. Engle recognises that extreme events in such analogues may not be a direct result of climate change and, thus, may not provide critical insights specific to climate change impacts (Engle, 2011). However, Engle (2011) agreed that adaptive capacity to any manmade or natural threat has similar traits. Engle (2011) also noted that, instead of assessing only the specific adaptations which provided resilience during an extreme event, factors which inhibit or facilitate adaptation, such as the structure, functions, and processes within the system must also be evaluated. However, due to the latent nature of adaptive capacity, limitations in characterisation and measurement of adaptive capacity are inevitable (Engle, 2011; Smit & Wandel, 2006).

Integrating vulnerability and resilience provides potential for robust adaptive capacity assessments. Engle (2011) found that assessing the factors that enhance adaptive capacity, due to a climate perturbation, can demonstrate the extent of adaptive capacity within a system during such an event. On the other hand, Engle (2011) recognised the characterisation of adaptive capacity as a different process where predetermined variables derived from extant literature can be measured quantitatively to explore potential adaptive capacity of the system, regardless whether the system is exposed to any climate perturbation. Engle (2011) suggested integrating these two approaches, based on a combined framework of vulnerability and resilience, to measure and characterise adaptive capacity.

In the first approach, advanced from the vulnerability framework, the impacts of a recent extreme event on a group of systems with consistent exposure and sensitivity can be studied to identify their adaptive capacity as an analogue of past events (Engle, 2011). Engle (2011) argued that in this approach, adaptive capacity must be evaluated as the dependent variable as impacts from disturbances are inversely proportional to adaptive capacity. Moreover, the independent variables of adaptive capacity must be directly proportional to adaptive capacity. Engle (2011) further claimed that this approach can be advanced to build a theory to develop the indicators of adaptive capacity, by identifying those with the highest influence. He believed such an approach can narrow down the multitude of indicators of adaptive capacity provided in the literature. Hence, only the indicators within the context of the system can be identified and measured.

The second approach proposed the resilient framework can be applied to understand adaptive capacity of the socio-ecological system (Engle, 2011). In this model, the system's preparedness and capacity to absorb disturbance in the face of a climatic extreme event, over different temporal scales, is evaluated (Engle, 2011). The basis for this approach lies in understanding the system's ability to adjust and adapt; therefore, proving the existence of adaptive capacity within the system. This approach can provide an understanding of the dynamic nature of adaptive capacity, thereby showing the factors, which enhanced or facilitated adaptation wherever it occurred. Engle (2011) suggested integrating both these approaches. Hence, the first approach identifies the indicators and the second approach determines how these indicators affect adaptive capacity during multiple periods of climate variations. Consequently, a mixed conceptual framework integrating both resilience and vulnerability frameworks can underpin understanding of adaptive capacity for robust research conclusions (Engle, 2011).

Integrated approaches in adaptive capacity assessments can also be found in economic frameworks. Williamson et al. (2012) suggested an integrated approach based on general equilibrium. In this approach, by assuming that there is a correlation between adaptive capacity, and economic and social outcomes, the outcome indicators can be used as proxy indicators of adaptive capacity. Williamson et al. (2012) argued that, by utilising this model, adaptive capacity deficits and the factors which cause these deficits can be identified through an integrated, interdisciplinary approach. Consequences of adaptive capacity deficits can then be identified to predict the potential for the emergence of future adaptive capacity deficits. Williamson et al. (2012) argued that most literature on adaptive capacity is based on retrospective assessments of coping responses after a disturbance. Consequently, anticipating future changes and ability of the system and environment to respond to such changes is challenging due to uncertainties in future climate change. Hence, uncertainties in climate extremes and variations must be considered in adaptive capacity assessments.

Uncertainties in future climate change can be addressed in research by using post-normal science. According to Funtowicz and Ravetz (1993), post-normal science is an external validation approach in environmental research to address the uncertainties in environmental threats and risks predicted for future. According to Saloranta (2001), the IPCC applies post-normal science in addressing uncertainty in technical, methodological, epistemological, and ethical domains. Conforming with post-normal science, a pluralistic, post-modern interdisciplinary approach is utilised in climate change predictions and modelling by IPCC (Saloranta, 2001). Consequently, the research methodology to study adaptive capacity must consider the pluralistic and interdisciplinary methods proposed in post-normal science, due to uncertainties in future projections on climate change threats and risks.

2.8 Adaptive capacity research from literature

Adaptive capacity has been studied under different, contexts, approaches and scales. For this thesis, studies related to the context of small communities were analysed; Table 2.3 provides a summary of some of the recent studies.

3. Table 2.3 Research on adaptive capacity

Author(s)	Methods	Key findings/ factors influencing adaptive capacity
Cinner et al. (2012)	• Studied 29 Western Indian Ocean communities across 5 countries (Kenya, Tanzania, Seychelles, Mauritius and Madagascar) • Contextualised livelihood adaptation to impacts on reefs • Quantified and aggregated 8 variables of livelihoods • Used normalisation and principal component analysis	• Availability of information on weather forecasts • Ability to evacuate from vulnerable areas • Diversification of livelihoods
Goulden et al. (2013)	• Studied Two Lake shore Ugandan communities • Used the "panarchy" model and a "synergistic approach"	• Availability of diverse resources • Social networking
Singh and Nair (2014)	• Assessed adaptive capacity of Western Indian farming communities • Fuzzy Cognitive Mapping integrated with sustainable livelihoods framework	• Organisational capital • Financial capital
Pandey, Babel, Shrestha, and Kazama (2011)	• Assessed adaptive capacity of freshwater resource systems in the Bagmati river basin of Nepal • Used an indicator-based framework and assessed the dimensions of, human capacity, economic capacity, natural capacity and physical capacity	• Economic capacity has the greatest influence on adaptive capacity, followed by natural and physical capacity
Angell and Stokke (2014)	• Studied adaptive capacity of Hammerfest, Norway, using a vulnerability framework	• Studied natural, socio-economic and institutional vulnerability and found that adaptive capacity is enhanced by economic growth of the region from oil industry
Chen et al. (2014)	• Used an integrated framework to quantify adaptive capacity of China at national and regional levels • Used a capital approach to determine an adaptive capacity index based on engineering capital, natural capital, human capital, financial capital, and social capital • An aggregate of 17 indices for five capitals was derived using 46 indicators • `Data were normalised and aggregated using equal weightings	• The ACI of 31 provinces showed that deficits in natural capital lowers adaptive capacity • Results indicate socio-economic development and investment in infrastructure and public utilities can compensate for the deficit of natural capital and can enhance adaptive capacity

McClanahan and Cinner (2011) evaluated adaptive capacity of 29 coastal communities in West Indian Ocean countries using a heuristic framework. The conceptual model was based on exposure, adaptive capacity, and ecological conditions, juxtaposed on the axes of x, y and z, to accommodate study sites based on specific social, ecological, and environmental characteristics. They used a measurable and normalised scale for the social, ecological, and environmental dimensions of adaptive capacity of the socio-ecological systems of coral reef dependent communities to the impact of coral bleaching due to global climate change.

McClanahan and Cinner (2011) evaluated eight determinants across three dimensions of socio-ecological and environmental clusters. These included: (1) recognition of humans' actions as the cause of the threat for coastal marine resources; (2) capability to anticipate change and to develop strategies to respond to reduction in fish stocks; (3) occupational mobility of people based on changes in occupation in last 5 years; (4) occupational multiplicity or number of people in a household with jobs; (5) social capital and networking; (6) material possessions of households; (7) technology used in fishing gear; and (8) public infrastructure. The indicators were normalised on a scale of 0-1, based on their significance on the adaptive capacity of populations. Indicators were weighted based on expert judgements and were aggregated using a linear aggregation model to determine the degree of adaptive capacity for each community.

McClanahan and Cinner (2011) concluded that adaptive capacity varies in communities across nations and within the countries, and economic diversity is the major determinant in enhancing adaptive capacity. They acknowledged that the study did not consider the actual threats, but it was based on the future predictions and climate scenarios of the IPCC. In addition, influence of low weight independent determinants on aggregate index of adaptive capacity was not evaluated. The study indicated limitations in using future predictions, as well as challenges in aggregation of indices from different determinants.

Maldonado and Moreno-Sanchez (2014) provided a practical methodology to determine Adaptive Capacity (AC) of local communities because of establishment of Marine Protected Areas in Latin America. They focused on household level adaptive capacity, in the context of households' ability to predict and respond to disturbances resulting from human and natural causes, by means of reducing, recovering, and coping. In this study, an Index of Adaptive Capacity (IAC), built on a resilience framework, was applied in a practical approach, consisting of socio-economic, socio-political, and socio-ecological dimensions. The IAC was determined through well-designed instruments, consisting of structured surveys and questionnaires.

According to Maldonado and Moreno-Sanchez (2014), the dimensions used captured the interdependence of the social and ecological systems in the study sites. To ensure the aggregation and comparison of indicators and sub-indicators for each dimension, data normalisation was carried out using a min-max approach, with a scale from 0-100, and included both qualitative and quantitative data. Indicators were given same weighting and data were aggregated using additive linear aggregation. Maldonado and Moreno-Sanchez (2014) highlighted that data aggregation should be tested for sensitivity by boot strapping to analyse sensitivity of the weights to changes, or by using a participatory exploratory technique.

To understand adaptive capacity to climate change in two lake shore communities of Uganda, Goulden et al. (2013) used the "panarchy" model developed by Westley, Carpenter, Brock, Holling, and Gunderson (2002), consisting of the four phases of, exploitation, conservation, release, and reorganisation. According to this model, a system with high resilience will adapt by shifting to a less desirable phase during a climate extreme or variation. They also used a synergistic approach based on the principles of bonding, bridging, and linking within the social system to study the social capital of the communities (Goulden et al., 2013).

Goulden et al. (2013) used random household surveys, based on wealth distribution among households, semi-structured interviews, focus group discussions, and stakeholder interviews with local and national level key informants. They also used an ordinal variable indicator to sample household resilience, which subjectively measured wellbeing of households based on perception. An exploratory phase, using rapid rural appraisal, was used to rank households and to select participants. They considered households as heterogeneous and dependent on the social capital. The authors demonstrated that a mixed methods approach using qualitative exploratory techniques can serve to verify the quantitative data. They used qualitative data from focus groups and semi-structured interviews to validate the quantitative data. During data transformations, the context and processes of adaptation, correlation of response to disturbances, and observed characteristics of social and natural capital of the system were considered.

In their data analysis, Goulden et al. (2013) used regression analysis of independent variables against an indicator of household resilience using SPSS. In analysing the qualitative data from interviews and focus groups, they used N-Vivo to code the information. They concluded that livelihood diversification and social capital may not always provide resilience as hypothesised: since the households are heterogeneous and do not accommodate resilient features for multiple disturbances in different time scales and, thus, are vulnerable to uncertainties. This study highlighted that in a community, households may have resilience for some disturbances, while being vulnerable to others and it is not necessarily determined by economic prosperity alone.

Using the rural livelihoods framework, Nelson et al. (2010) studied adaptive capacity of Australian rural communities to climate change, as a reflection of the diversity of resources and livelihood activities. The context of the research was based on the capacity to substitute resources and livelihoods against the'' threats from climate variations. Nelson et al. (2010) argued that adaptive capacity relies on a balance of the five capitals of social, human, natural, physical, and financial dimensions, which also determine the rural livelihoods. To derive an adaptive capacity index from rural livelihood analysis, Nelson and others used principal component analysis and weighted three indicators for each of the five capitals, non-parametrically. The indicator values were aggregated to derive a composite index of adaptive capacity. The results indicated that communities faced with climate disturbances can cope appropriately if they can utilise available resources efficiently (Nelson et al., 2010).

Major limitations of these studies are the lack of evaluation of subjective adaptive capacity, and motivation of people to take necessary actions. Most of these studies show objective adaptive capacities based on wealth and resource availability. In these studies, economic factors are considered the foremost determinant of adaptive capacity. However, research has shown that objective capacity based on wealth and resources does not reflect subjective adaptive capacity, or the ability to respond to threats (Grothmann & Patt, 2005a). To address such limitations, socio-psychological models were utilised in this research to evaluate adaptive capacity.

Grothmann and Reusswig (2006) used the PMT model to study why some people take precautionary action against flooding in Germany. Grothmann and Reusswig (2006) collected data on residents' private actions for flood prevention based on perceptions of previous flood events, perceptions on risks of future floods, reliability of public strategies to protect from floods, efficacy and costs for private actions, perceptions on ability to take private actions, and non-protective actions, such as wishful thinking. They used quantitative telephone surveys and regression analysis to compare various socio-economic indicators against how people responded. Their study showed that, people's actions under the threat of flooding can be predicted more efficiently using this model, instead of a socio-economic indicator-based assessment. Their results also indicated net household income is not significant in adaptive capacity, opposing most studies which indicate income, wealth, and resources as major determinant in adaptive capacity. In another case study by Grothmann and Reusswig (2006) on proactive adaptation of Zimbabwean farmers to drought, it was found that when people perceive a lack of adaptive capacity or ability to act, they have low intentions to respond to droughts. Using the PMT model to study adaptation actions of farmers in Sri Lanka, Truelove et al. (2015) found the model was more efficient in predicting adaptive behaviour and actions than a demographic model. Their study also found that perceived ability is critical for farmers' adaptive capacity.

2.9 Summary

This chapter has provided an in-depth analysis of adaptive capacity in an island context. The chapter was introduced with climate change and adaptive capacity of small islands within a Maldivian context. This was followed by a critical review of adaptive capacity from literature. The literature revealed adaptive capacity as a complex, latent, and multi-disciplinary concept. The review provided definitions, determinants, theories, and frameworks of adaptive capacity. In addition, methodologies for characterisation and evaluation of adaptive capacity, and studies conducted using such methodologies, were explored.

According to the review, the islands of the Maldives are faced with unprecedented threats from global climate change. Impacts predicted from global and local models, for 2081 to 2100, suggest an increase of sea level by 0.40 to 0.48 meters and temperature increase of 1.8˚C, while precipitation is expected to be erratic with heavy short bursts and a general increase of 9 percent compared to baselines. These projections indicate 44 percent of settlements within 100 meters of coastlines, and 80 percent of land a meter above sea level, could face severe threats of submergence by 2080. According to the present review, the Maldives has been passionately advocating on climate change at a global level for more than a quarter of a century. The review also found the evolution of the society and nature of Maldivian islands, from the past to the present, as having poor governance and socio-economic structure, as well as heavy external influences from modernisation and globalisation. According to the review, these factors have weakened the traditional resilience mechanisms established within the islands. However, the review showed strengths of island societies, such as strong kinships, local living economies, and social bonding and linking.

This chapter also analysed the importance of using a pragmatist approach with a multi-disciplinary, mixed methodology to study adaptive capacity of islands to climate change. In this regard, the review emphasised the importance of theories of islandness, protection motivation theory, theory of reasoned action, economic theories, including demand and utility theory, as well as theory of social capital. The analysis showed that, based on these theorisations, different frameworks can be drawn upon from resilience, socio-ecological systems, vulnerability, political ecology, and livelihoods to frame adaptive capacity. The review indicated the role of islandness and protection motivation theory of adaptive capacity in understanding adaptive capacity of islands through adaptive behaviour and actions of people. According to the review, framing adaptive capacity of islands, by integrating a livelihoods framework within a socio-ecological systems approach, will provide a robust methodology to characterise and evaluate adaptive capacity of islands. The review also indicated importance of using a mixed methodology emphasising both constructivist and positivist paradigms. Based on this review, a conceptual framework was developed to study adaptive capacity of islands and to develop the methodology for the thesis. The next chapter will discuss the methodology.

CHAPTER 3: RESEARCH METHOD

3.1 Introduction

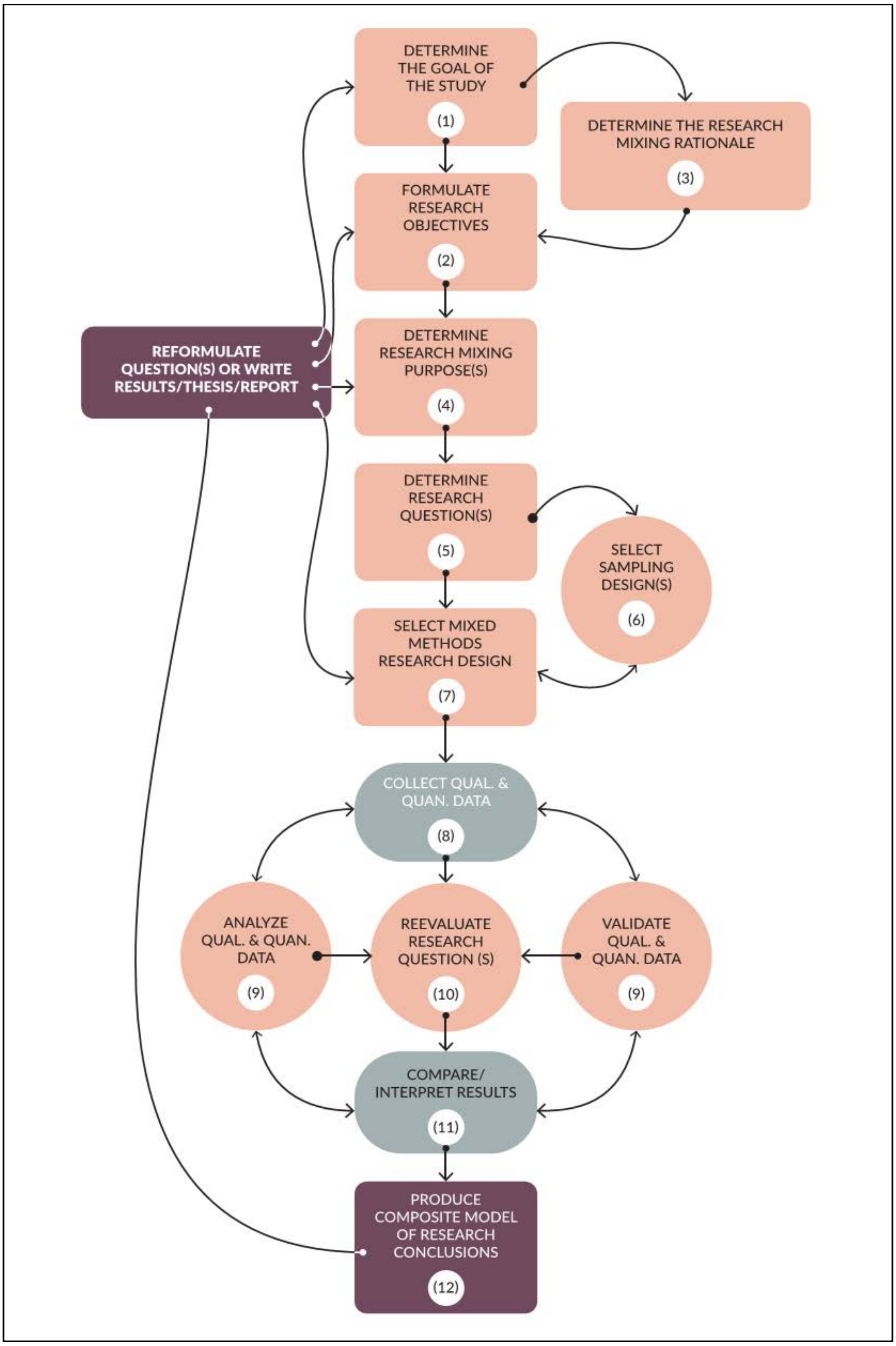
This chapter lays out the research approach and strategy of this thesis. It provides an overview of the methodology, methods, and validation of methods utilised to answer the research questions outlined in Chapter one. This chapter sets forth the convergent, parallel, mixed, methodology utilised in this thesis to fulfil the research aim of identifying the potential for and limits to climate change adaptive capacity in the islands of the Maldives. Finally, this chapter discusses the methodological challenges and limitations of the research. This research was approved under the permit (H6051) of the Human Research Ethics Committee of James Cook University, and the research protocol was guided and monitored by a primary and secondary advisor.

The objective of this thesis is to assess the adaptive capacity of islands of the Maldives based on the social and ecological attributes of the islands. Adaptive capacity is a complex, nonlinear, latent, and interdisciplinary phenomenon (Engle, 2011), as detailed in Chapter two. Hence, a quantitative analysis, based on external objective observations alone, will not suffice for the robust research methodology required for this thesis (Engle, 2011). Therefore, subjective interpretation of people's experiences is essential to understand adaptive capacity (Engle, 2011). In this thesis, quantitative methods are used to understand the correlational and probabilistic aspects of adaptive capacity. Quantitative methods included measuring changes in the biogeophysical environment of the islands using Arc GIS tools. In addition, quantitative measurement of adaptive capacity with an indicator-based assessment was carried out. Qualitative methods are used to understand subjective and objective aspects of adaptive capacity, influenced by socio-economic, socio-cognitive (Grothmann & Patt, 2005a), and institutional and governance aspects (Engle & Lemos, 2010), within the island communities. Consequently, both a positivist approach of objective observations, and a constructivist approach of subjective interpretations were utilised to draw research inferences (Creswell, 2014).

3.2 Research paradigm

Epistemological view of pragmatism integrates both qualitative and quantitative methodologies (Bak, 2011), in the context of finding "what works" (Teddlie & Tashakkori, 2009), and "why and how" it works (Yin, 2009), as well as how human and natural systems interact (Greene, Caracelli, & Graham, 1989). Thus, the living phenomenon of adaptive capacity of islands can be understood through the paradigm of pragmatism. Subsequently, this research takes into account the epistemological philosophy of multiple ways of arriving at knowledge and ontology of pluralism, with the perspective of complex and multiple realities (Johnson et al., 2007). In conclusion, the research paradigm to assess adaptive capacity was based on dialectical pragmatism, utilising insights from both qualitative and quantitative methods (Johnson et al., 2007).

Though Mixed Methods (MM) research philosophies became popular at the beginning of the 20th century, quantitative methods dominated social science research from the beginning of 1930s (Johnson & Gray, 2010). However, concepts of MM re-emerged in the 1950s, and by the 90s, MM became a major methodological paradigm (Johnson & Gray, 2010). MM has gained popularity in the study of human dimension of climate change. Elwood (2010) acknowledged a mixed methods approach is essential to achieve complementarity from multiple methods, whereby strengthening research inferences. Additionally, MM create novel knowledge through integration of different methods of analysis, interpretation, and epistemology (Elwood, 2010). For instance, qualitative methods of interviews provide meanings, relationships, and interactions, while quantitative methods, such as surveys, provide broader correlation patterns on cause effect linkages (Elwood, 2010). According to Creswell (2014), a convergent, parallel, mixed method involves both qualitative and quantitative methods in data collection concurrently, and analysis is triangulated by transformation of data to arrive at a research conclusion. Following the mixed methods approach of Collins, Onwuegbuzie and Sutton (2006), and Creswell (2014), Figure 3.1 shows the multi-stage process adapted for the mixed methods research in this study. The sections below will provide further methodological details.



10. *Figure 3.1 Outline of the mixed methods research design, adapted from Collins, Onwuegbuzie, and Sutton (2006)*

3.3 Conceptual framework for studying adaptive capacity of islands.

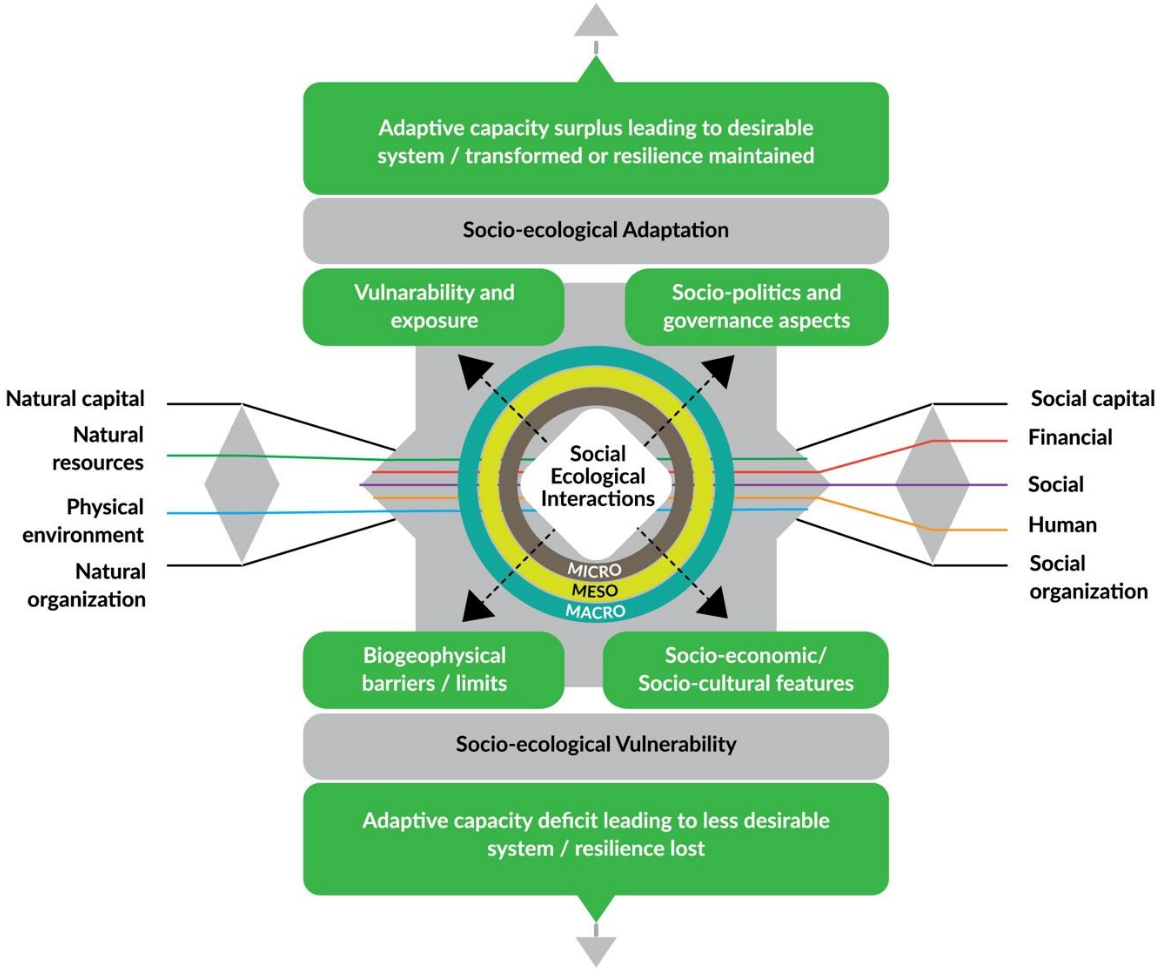
In this research, an integrated conceptual framework, based on resilience and vulnerability of the socio-ecological system of the islands, was adopted (Figure 3.2). In this conceptual model, society, and nature of small islands are viewed as a socio-ecological system, where nature and society assimilate in to an inseparable complex, governed by interdependent interactions (Berkes, 2011). Adaptive capacity in any socio-ecological system is regulated by resilience (Folke & Berkes, 2000). Resilience in general is dependent on heterogeneity, diversity and ability to sustain socio-ecological interactions within the system (Folke, 2006). In other words, the system must have the capacity to absorb variables which influence the natural state and parameters, while remaining persistence with the change (Folke, 2006). In a resilient socio-ecological system, adaptive capacity is enhanced via social factors, such as informed ecological knowledge, flexible governance, and diverse livelihood opportunities, as well as ecological factors, such as rich biodiversity, and abundant key species with comprehensive ecological niches pertinent to healthy ecosystems (Berkes et al., 2003; Folke & Berkes, 2000). Consequently, adaptive capacity of such a system can be expressed as the capacity of the system to adapt, to any anticipated or prevailing conditions, through self-organisation, learning, and reasoning (Norberg & Cumming, 2008). In this study, the islands of the Maldives are considered as socio-ecological systems regulated by natural forces and human interactions, through socio-economics, culture, governance, and politics.

According to the conceptual model of this study (Figure 3.2), adaptive capacity is governed by socio-ecological interactions, regulated by the socio-ecological organisation encompassing natural organisation and social organisation. Natural organisation represented on the left (Figure 3.2) consists of the physical environment and the biotic environment in and around the island. In the Maldivian islands, natural environment consists of low-lying coral islands surrounded by coastal marine environment. Social organisation represented on the right (Figure 3.2) consists of economic, cultural, and political subsystems. Both the natural organisation and social organisation are interrelated, and are influenced by socio-ecological interactions pertinent to human interactions and actions, as portrayed in the centre of the diagram (Figure 3.2). Social and natural systems are interlinked through these interactions, organised within the socio-ecological system.

The natural and social organisation falls within five inter-related characteristics of adaptive capacity in local communities, as defined in the local adaptive capacity framework: "*the asset* *base; institutions and entitlement; knowledge and information; innovation; and flexible forward looking decision-making*" (Jones, 2011a, p. 4). In this research the above determinants are analysed in an island context as: (a) biogeophysical characteristics; (b) socio politics and governance; (c) climate change vulnerability and exposure; and (d) socio-economics and socio-cultural factors. These characteristics can be elaborated within three overall dimensions as socio-ecological, socio-economic, socio-cultural, and institutional dimensions, to understand adaptive capacity of islands. These dimensions are interconnected with the socio-ecological interactions of the islands at micro (individual and household), meso (local community), macro (national), and to some extent, the mega (international) level. Each of these dimensions is influenced by multiple indicators, pertinent to adaptive capacity. These indicators interact within the socio-ecological system, creating deficits and surpluses in adaptive capacity. As shown in this conceptual framework, deficits in socio-ecological interactions lower adaptive capacity, while surpluses enhance adaptive capacity, leading to a more desirable system, or a resilient system (Jones, Ludi, & Levine, 2010b; Williamson et al., 2012). However, isolation, remoteness, and scale of impacts of climate change can significantly impact these deficits and surpluses. Hence, adaptive capacity of an island is influenced by socio-ecological interactions governed by different variables or determinants within different contexts and scales.

SIDS, such as the Maldives, are faced with major challenges due to weak democratic governance and scarce resources. In contrast, the egalitarian welfare societies of western European democracies (as shown by Duchhart (2007), based on the Kleefman Model) demonstrate that the socio-ecological system is regulated and maintained through legitimacy, garnered via social consensus and electoral incentives. Consequently, to ensure that the principles of social and natural organisation do not diverge, creating deficits in adaptive capacity, a well-functioning democratic governance system is crucial, especially when natural resources are deficient and when people and their biogeophysical environment are vulnerable (Duchhart, 2007). Accordingly, adaptive capacity of society and nature of islands of the Maldives is largely determined by the extent of divergence of regulating principles pertinent to socio-culture, socio-economics, and governance, corresponding to the socio-ecological organisation of the islands. Divergence of these principles can cause deficits within the socio-ecological system, leading to lower adaptive capacity. In conclusion, adaptive capacity in small islands is regulated by natural, economic, cultural, and governance dynamics integrated within the socio-ecological system.

This conceptual model was used as a guide for the convergent, parallel, mixed methodology in determining the research strategy, and qualitative and quantitative instruments chosen for the research.



11. Figure 3.2 Conceptual model of research.

Derived from modified model of Kleefmann by Duchhart (2007), and information from Berkes et al. (2003), Engle (2011), Williamson et al. (2012), to show how natural capital and social capital interrelates to form the socio-ecological interactions

3.4 Research approach

Research on adaptive capacity began in 2000s, and has intensified recently as a proxy to understand the existing adaptation mechanisms and strategies (Mortreux & Barnett, 2017). From the beginning of adaptive capacity assessments until now, assets based theories derived from sustainable livelihoods, using indicator based assessments, have been utilised (Mortreux & Barnett, 2017). In social sciences, the premise for the human dimension of climate change is based on the consensus of humans as the responsible agents of global climate change, instead of positing adaptation as a requirement for human societies (Bruce, Kelly, Robert, & Ailbhe, 2015). For this reason, different research traditions and methods have been employed in studying climate change adaptation. The five research traditions most commonly used in social sciences are: ethnography, narrative research, grounded theory, phenomenology, and case study (Creswell, 2013). Accordingly, these traditions are explored to study the adaptive capacity of islands.

Adaptive capacity is considered as a living situation and a complex multidisciplinary phenomenon. Hence, in this study, a mixed methods research design was developed by integrating both qualitative and quantitative methods (Creswell, 2014). In this study, empirical data were obtained from interviews, Participatory Climate Change Adaptation Appraisal (PCCAA), and secondary sources. According to Denzin and Lincoln (2005, p.3), qualitative data obtained from empirical sources can help to explore the "routine and problematic moments in individuals' lives". Herbert (2000) believed that qualitative methodologies are essential for an in depth understanding of the complexity of socio-ecological connections.

In this study, an analogue comparative case study approach was utilised (Ford et al., 2010; Yin, 2009). Ford et al. (2010) recognised analogue methodology as a means of understanding a subject through knowledge gained from similar subjects. They also found that analogues can be temporal or spatial. According to Ford et al. (2010), temporal analogues utilise the information from the research subject's past and present to infer future responses to climate change impacts. On the other hand, spatial analogues are utilised to study the current context of a location to infer results for other parallel locations of interest (Ford et al., 2010). In this research, both temporal and spatial analogues were utilised, based on a comparative case study pertinent to a phenomenological case study.

3.4.1 Analogue comparative case study methodology

Case study designs are developed to frame both the phenomena being studied and the context of the phenomena (Yin, 2009). Yin (2009) believed that, in case study designs, the phenomenon being studied, and its context must be integrated, to cater for pragmatic inquiry of variables and their influences. Thus, case studies are critical to unpack the perceptions and understanding of people pertinent to a phenomenon within a unit of analysis, by a thorough focus on key stakeholders' lived experiences (Theodoridis, 2014). Consequently, a case study method is ideal to study the adaptive capacity of islands.

Case studies characterise multiple paradigms, epistemologies, or methods (VanWynsberghe & Khan, 2007). VanWynsberghe and Khan (2007) argued that a case study is a *"trans-*

paradigmatic and transdisciplinary heuristic that involves the careful delineation of the phenomena" (p. 90). They believed that case studies fit within any paradigm or discipline. Seven characteristics of case studies, identified by VanWynsberghe and Khan (2007), are: (1) small sample size; (2) highly detailed and contextualised analysis; (3) minimum direct interference of the natural world by researcher; (4) bounded within a specific temporal and spatial scale; (5) coevolution of hypothesis and inferences with the progress of the findings; (6) gathering of data from multiple instruments; and (7) comparability of inferences to other similar cases. Hence, a case study methodology was considered the most suitable for this thesis, to apply a convergent, parallel, mixed method design.

3.4.2 Case study in climate change research

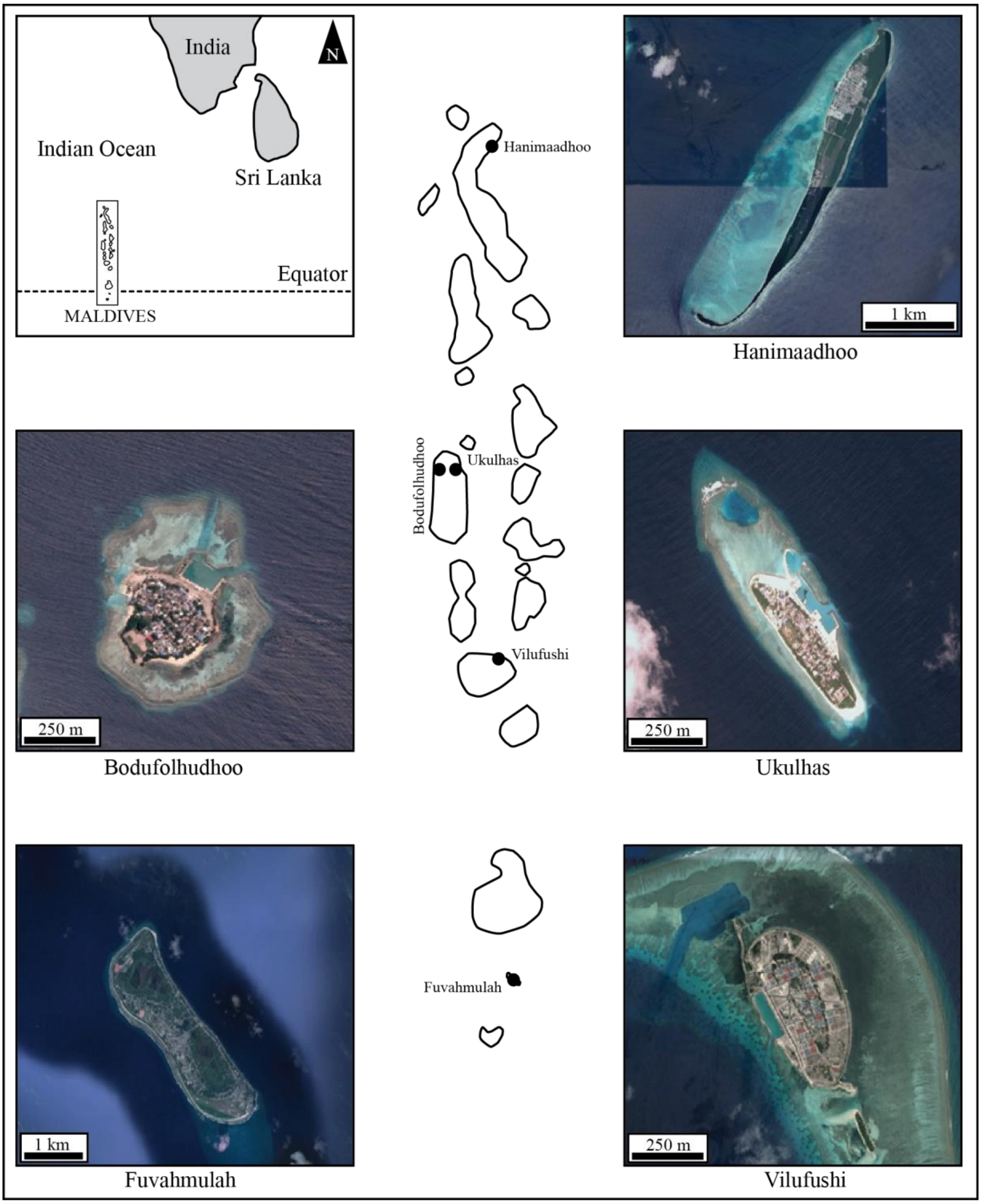
Case studies are widespread in the study of climate change in both physical sciences and social sciences (Ford et al., 2010). Ford et al. (2010) found that case studies, advanced from 1970s case studies based on hazards research, have become prominent in the 90s in the study of human dimension of climate change. Even though case study methods are well established, inevitable limitations are encountered. For instance, Yin (2009) found that the lack of generalization of findings from case studies to a broader level is a major limitation. Consequently, in designing a case study, a unique set of terms, priorities, and conditions related to the research problem must be delineated (Berg & Lune, 2012). Drawing from Yin (2009, p. 27), I focussed on the following design elements for this case study research, based on the research outline given in Figure 3.1:

- Study's questions
- Study's propositions
- Unit(s) of analysis of the case study
- Logic behind linking the qualitative and quantitative data to the propositions
- Criteria for determining inferences from the findings

In Chapter one of the thesis, the study's propositions and questions were detailed. In Chapter two, the small islands of the Maldives and their socio-ecological system, as a unit of analysis, was detailed. The following sections will describe the research processes followed.

3.4.3 Island selection criteria

Case studies are typically embedded within a specific locality (Ford et al., 2010). Consequently, samples for case studies must be selected for replication (Yin, 2009). Choice of cases should be determined by their similarities to each other, or differences from each other (Perry, 1998). Perry (1998) favoured a purposive sampling approach, using maximum variation sampling when cases need to be selected to determine significant variations. Perry (1998) claimed that maximum variation sampling can provide rich data for robust research conclusions. In addition, cases must be selected based on research context, and a minimum of two to four cases must be studied (Perry, 1998). Drawing from Perry (1998), and guided by the conceptual framework of the research, five islands with maximum variations were purposively selected for this study, as a representative sample of inhabited islands of the Maldives. The islands were selected based on a criterion set by the government of the Maldives in the study of climate change adaptation, as given in the Adaptation Analysis by MHE (2010). According to these criteria, islands were selected based on demographic, geographic, and environmental features. These included population density, geographic coverage, location within the country, environmental features, urbanisation, and the administrative status of the islands. Tables 3.1 and 3.2 show these criteria and the characteristics of the islands sampled. Figure 3.3 shows the islands chosen for the study.



12. Figure 3.3 Google Earth image of islands selected for the study

4. Table 3.1 Island selection criteria

Criteria used in island case selection	Islands selected for the study				
	Hanimaadhoo	Ukulhas	Bodufolhudhoo	Vilufushi	Fuvahmulah
Land use and urbanisation (high, medium, low)	Low	High	very high	High	Medium
Geographic coverage within the Maldives (north, central, south)	Northern region	Central	Central	South Central	South
Location within the atoll (atoll rim or inner atoll)	Atoll rim (Eastern periphery)	Inside atoll rim	Centre of atoll	Atoll rim (Eastern periphery)	Single reef top island
Island Size >100 hectares to <100	> 100	< 100	< 100	< 100	> 100
Island orientation North to South / East to West / Circular	N-S	E-W	Circular	N-S	N-S
Population density > 30 per hectare or < 30	< 30	< 30	> 30	> 30	< 30
Population size	1500- 2000	500- 1000	200- 600	500- 1000	5000 and above
Administrative status of island (atoll capital or not)	Not a capital	Not a capital	Not a capital	Not a capital	Capital island and a City
Major reclamation and coastal interventions (minimum intervention to heavy modification)	Minor	Major	Minor	Major	Minor

All * registered households may not be occupied. Some may be under construction or abandoned. Some may be used for commercial purposes such as cafes, carpentries or shops. On average, about five percent of households may be unoccupied.

5. Table 3.2 Key demographic and geographical characteristics of case study islands

Island Name	Atoll where island is located	Geographic location	Approx. Size/ hectares	Key geographic and environmental features	Population			No. of *registered households	Sample sizes		
					Total	Male	Female		No. of Survey responses	No. of Interviewees	No. of focus groups
Hanimaadhoo	Haadhaal Atoll	Upper North	300	A large island with an airport and several infrastructures, and a large migrant community consisting of people from different islands.	1616	790	826	315	51	5	2
Ukulhas	Alif Alif Atoll	Central	17	A small island with several economic activities and a very active community.	921	469	452	136	28	5	2
Bodufolhudhoo	Alif Alif Atoll	Central	11	A very small island with high population density surrounded by resorts.	584	292	292	79	20	5	2
Vilufushi	Thaa Atoll	South Central	57	An island completely rebuilt after the 2004 Indian Ocean tsunami, with huge revetments around the island. The island is also reclaimed and was raised to an elevation of 3 metres. It was repopulated in 2007 after rebuilding.	976	463	513	309	37	5	2
Fuvahmulah	Gnaviyani Atoll	South	530	One of the five largest islands of the Maldives, which has two fresh water lakes. It is heavily developed and urbanised, with diverse economic activities with strong social capital.	7984	3612	4372	1898	101	7	2

3.5 Research Methods

3.5.1 Overview of research methods

Research instruments for this study were determined by the research questions and the conceptual framework. The research involved both inductive and deductive methods of inquiry, representing different aspects of social reality (Layder, 2013). Henceforth, the research methods involved mixed methods. The approach focused on understanding the elements, enabling conditions and features of socio-ecological system of islands which influence their adaptive capacity, known as determinants of adaptive capacity (Smit & Pilifosova, 2003). These determinants of adaptive capacity are closely linked to livelihood-based assets, tailored within the social, natural, physical, financial, and human capitals (Moser & Stein, 2011), as discussed in Chapter two. Table 3 describes the research matrix used for the thesis. The following sub-sections will describe details of methods used.

6. Table 3.3 Research matrix, with the research questions, methods, data instruments, and line of enquiry

Research questions	Objectives	Dimension/ Criteria		Indicators	Variables	Method/ instruments	Line of enquiry
• **What socioeconomic, biophysical and governance variables influence adaptive capacity of small islands?** • **How do these variables influence adaptive capacity thresholds of the islands?**	To evaluate the socio-ecological factors influencing adaptive capacity and their cause and effect relationships To assess the degree of resilience, adaptive capacity and vulnerability of islands to future climate change	Socio-economic Dimension	Economic Resources and economic development	Livelihood diversity index	• Economic activities • Occupational multiplicity	HS	• Is the valuation of adaptive capacity based on both tangible and non-tangible capital? • Do the socio-economic factors enhance an enabling environment for adaptive capacity? • To what extent do the government, private sector and NGOs enhance social capital, social networks, equity and community initiatives for adaptive capacity? • What are the coping and adaptation strategies? • How does lack of adaptive capacity affect community? • Which households are more resilient? • What benefits has adaptation brought to the islands? • What are the main resources and livelihood strategies that enhance households' adaptive capacity?
				Assets Infrastructure and Services	• Sewerage and water networks(storage)/ • Flood protection • Housing • Infrastructure • Transportation • Household level assets	HS SS II	
				Employment and Financial sources	• Occupational mobility • Average incomes • Livelihood opportunities • Remittances	HS	
				Migration	• Places of migration • Age of migration • Number of months away • Reasons for migration	HS	
			Adoption of Technology	Availability and accessibility	• Technologies available to cope • No. of households having access to technology • Affordability and relevance	HS	
			Social Networks	Social bonding	• Participation in social activities	HS	
				Practice of reciprocity	• Family support structures • No. of households receiving assistance from others • No. of households giving assistance to others	HS	

Research questions	Objectives	Dimension/ Criteria		Indicators	Variables	Method/ instruments	Methods/Line of enquiry
• **What socioeconomic, biophysical and governance variables influence adaptive capacity of small islands?** • **How do these variables influence adaptive capacity thresholds of the islands?**	To evaluate the socio-ecological factors influencing adaptive capacity and their cause and effect relationships To assess the degree of resilience, adaptive capacity and vulnerability of islands to future climate change	Biophysical Dimension	Conservation and sustainability of natural resources	Sustainability of natural resources	• Status of biodiversity • Number of protected areas • Coastal erosion status and land loss • Ground water quality	FG II SS	• What characterises adaptive capacity of islands? • Which households have capacity to cope climate change impacts? • How do climate change impacts affect natural resources and livelihoods? • Does the perceived changes to climate and weather patterns effect decisions of households?
				Urbanisation	• Changes in land use over 30yrs • Increase in urbanisation	SS	
				Ecological vulnerability	• Elevation of island • Zones of high risks in case of climate change related perturbations	SS FG	
			Climatic variability	Changing weather patterns and climate change related perturbations	• Climate change impacts and threats most critical to islands • Identification of extreme • events and patterns of events • Number of extreme events (last 10yrs) • Intensity of extreme events • Categorization of threats and impacts of extreme events • Number of households affected • Households with capacity to cope	SS FG II IO HS	

Research questions	Objectives	Dimension/ Criteria		Indicators	Variables	Method/ instruments	Line of enquiry
• **What socioeconomic, biophysical and governance variables influence adaptive capacity of small islands?** • **How do these variables influence adaptive capacity thresholds of the islands?**	To evaluate the socio-ecological factors influencing adaptive capacity and their cause and effect relationships To assess the degree of resilience, adaptive capacity and vulnerability of islands to future climate change	Governance and Policy Dimension	Governance/Policies	Role of councils	• Local governance mechanism • Decision making • Budgets and facilities • Efficiency in delivering services • Networking within institutions	PCCAA/FG SS II IO	• What role does institutions play in enhancing adaptive capacity? • Does a well-functioning and enabling environment exist? • What is the role of government, organisations and private sector in enhancing adaptation? • Level of autonomous, proactive and reactive adaptation and maladaptation? • Adaptive behaviour and actions depicted by households, government, and organisations? • How is the current development pathway affecting adaptive capacity? • What social, demographic, economic and political characteristics of households enhance adaptive capacity? • What are the main coping and adaptation behaviours of households? • How important are formal and informal institutions? • How are personal networks utilised for adaptive capacity?
				Policies related to climate change	• Coverage and objectives • Number of programs • Benefits to island community	FG II IO	
				Role of Cooperation	• State and civil society networks • Strengths and gaps in different governance levels • Public consultation in adaptation projects	PCCAA/FG SS II IO	
			Information and Awareness	Information and awareness on climate change	• Weather and climate related information availability • Accessibility to education • Information sources in island • Utilisation of information	PCCAA/FG II IO HS	
			Social Stability	Social networking	• NGOs in island • NGO activities	PCCAA/FG II	
				Crimes and stability	• Crimes and safety • Sense of belonging • Motivation to resettle or remain in the island	PCCAA/FG II HS SS	

For some of the variables and indicators, data were integrated from different instruments.

SS- Secondary sources; FG- Focus groups (PCCAA, Participatory Climate Change Adaptation Appraisal); II-Interviews with islanders; IO-Interview with officials (government and NGOs); HS-Household survey

3.5.2 Participatory Climate Change Adaptation Appraisal (PCCAA)

The main objective of the qualitative component of this study was to explore issues, ideas, and queries regarding adaptive capacity in islands, by analysing the actions and interactions of people in adopting innovation, enhancing good governance, and reducing maladaptation. Consequently, participatory methodologies developed from participatory rural appraisals as a bottom up approach were utilised to obtain and understand the local people's perspectives, voices, and priorities (Moser & Stein, 2011). Moser and Stein (2011) maintained that PCCAA is a community approach, which aims to understand impacts of climate change and community adaptation where macro level analysis is insufficient. Moser and Stein (2011) recognised that, like in participatory rural appraisal (PRA) and rapid rural appraisal (RRA), PCCAA is also rooted in various participatory exercises, such as focus groups designed to obtain insights on resilience and adaptation. Consequently, PCCAA, pertinent to local adaptive capacity framework, was integrated with the theory of islandness to study adaptive capacity.

PCCAA participants preselected for this study were organised into focus groups. Focus groups are used as a data collection method to explore adaptive capacity through group interactions (Morgan, 1996). In PCCAA, data were generated through group discussions and activities involving active participation of a researcher with focus groups, to explore themes developed to understand adaptive capacity (Moser & Stein, 2011), based on the theory of islandness. Morgan (1996) found that most focus group methods are utilised in combination with in depth interviews and surveys, and is one of the most practical designs to triangulate different qualitative and quantitative data. Hence, in this research, PCCAA with preselected focus groups were used for complementarity, followed by interviews and household surveys conducted concurrently (Morgan, 1996).

3.5.3 Interviews

Interviews are regarded as one of the most important data collection tools in field studies and ethnographic methodologies (Dumay & Qu, 2011). In this study, semi-structured interviews were conducted to explore adaptive capacity deficits and causes, to explore the cause-effect linkages of different determinants of adaptive capacity. The interviews were regarded as structured conversations to explore knowledge of participants, built on their own experiences, in the context of adaptive capacity (Dumay & Qu, 2011). The approach was based on the "localist" perspective, outlined by Alvesson (2003), where the interview was regarded as an empirical process examined through narratives provided as situated accounts of the phenomenon.

The semi-structured interviews involved carefully designed questions based on themes relevant to adaptive capacity, administered through a consistent and systematic routine (Dumay & Qu, 2011). The flexibility, accessibility, and intelligibility of semi-structured interviews, which entails disclosure of hidden aspects of human behaviour, allows the researcher to understand how interviewees perceive the social world (Dumay & Qu, 2011). Dumay and Qu (2011) also emphasised that semi-structured interviews utilizing the "localist" approach is not merely a process to induce rational answers to discover the truth, but a situated event whereby the interviewer creates the reality of the phenomena of interest. The interview protocol was designed to ensure consistency, for comparison among case study islands.

3.5.4 Questionnaire surveys

In this study, households have been integrated within the individual case islands, as embedded units of analysis (Yin, 2009). The logical choice for using households as embedded units of analysis was to understand varied capacities or potentials for adaptiveness among households, which in turn governs adaptive capacity of the island community. Additionally, adaptive capacity assessments conducted at macro scales, such as at national level, may obscure meso and micro scale barriers, limits, vulnerabilities, and opportunities, such as at household and community levels (Adger, Barnett, Brown, Marshall, & O'Brien, 2013). Households also take adaptive actions, both consciously and unconsciously, without explicitly having information about climate change or prioritising adaptation on a cognitive basis (Toole, Klocker, & Head, 2015). Therefore, understanding adaptive behaviour and responses at local socio spatial scales, such as at household levels, is critical to determine adaptive capacity at an island level (Toole et al., 2015).

In this study, household surveys were used as a quantitative method. Yin (2009) agreed that surveys are chosen in embedded case studies to make causal inferences, which are seldom possible from a single method. Quantitative research also offers relationships between variables and how the variables are located and spread, and their relationships with each other, where reality may be conceptualised from the variables quantified (Keith, 2003). The main purpose of the survey was to derive an Adaptive Capacity Index (ACI) as a quantitative measure of the capacity of the small island communities to cope and manage climate perturbations (Moreno-Sánchez & Maldonado, 2013; Smit et al., 2001). The ACI was adapted from the methodology given by Maldonado and Moreno-Sanchez (2014) and Moreno-Sánchez and Maldonado (2013).

3.6 Research sampling

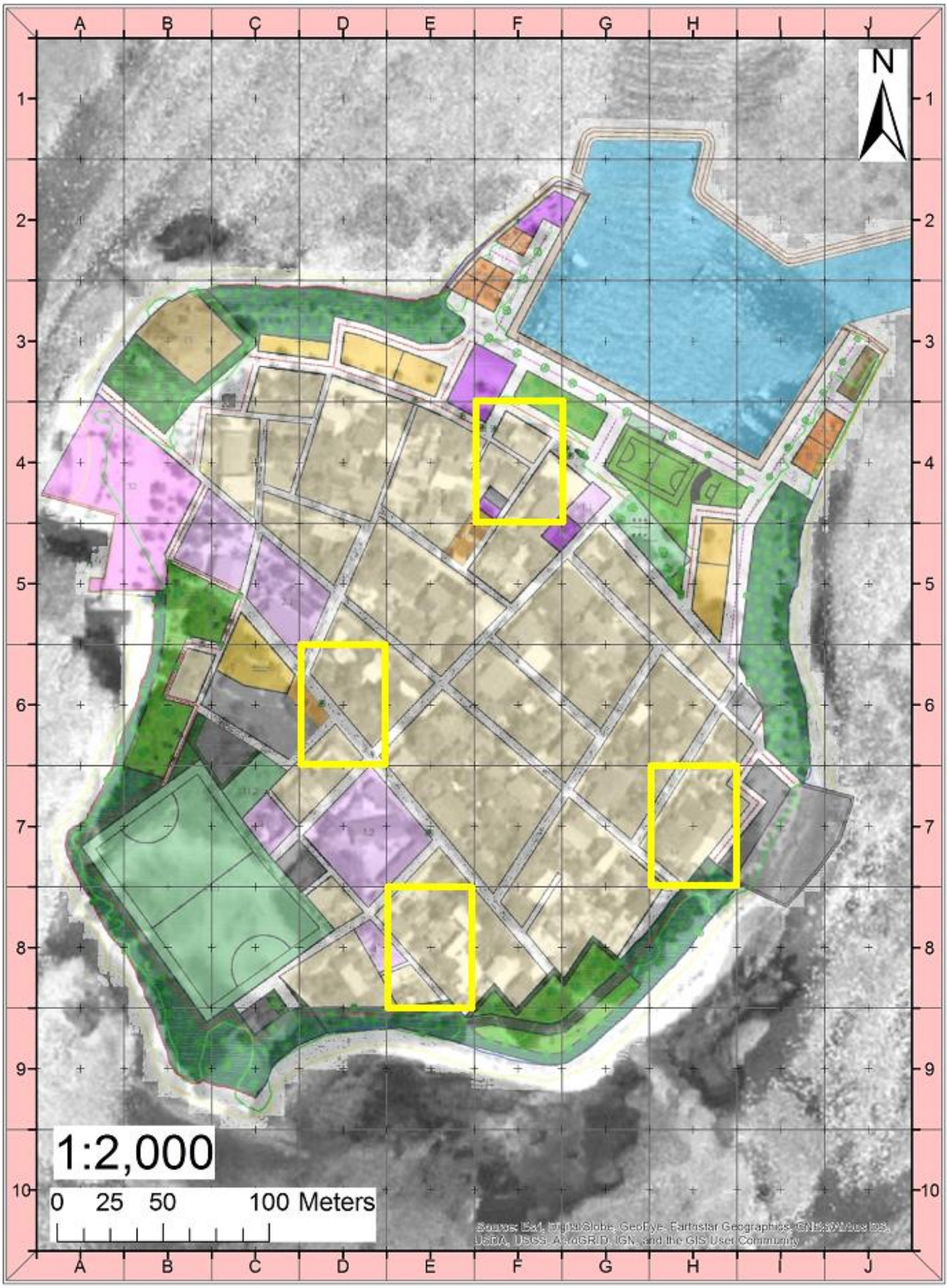
Drawing from Johnson (2014), I used a mixed sampling design, determined by time orientation, and sample relationship. Qualitative and quantitative data were collected at the same time from separate samples. Johnson (2014) referred to this design as concurrent, parallel sampling. The sampling scheme and the sampling size for the research was based on the sampling criteria for mixed methodologies, given by Collins et al. (2007). According to Collins et al. (2007), representativeness in sampling sizes must be determined based on the data requirements for each research instrument, and must be compatible with the design of the research instruments. Sampling methods for each research instrument will be described in the sections below.

For the PCCAA, two focus groups, covering a full day, were conducted on each of the five islands: distinct male and female focus group of six to eight participants was formed by preselecting participants from the case study islands. Participants were recruited through consultation with island councils, as I had minimum contact or knowledge of key stakeholders from the island prior to the field visit. Purposive sampling of key stakeholders from the islands was carried out to ensure a diverse representation of island community was obtained for PCCAA and interviews. Each of the island's councils were requested to select six to eight male and female participants for the PCCAA. The island councils were instructed to select key stakeholders representing various economic and social backgrounds within the island. In case of Fuvahmulah, two wards were combined, and participants were selected from the two wards, due to the size of the island. Preselected groups were used instead of random groups, due to limitations in resources and time. Participation in focus groups was voluntary and participants were allowed to move out whenever they wanted to abstain from the discussions.

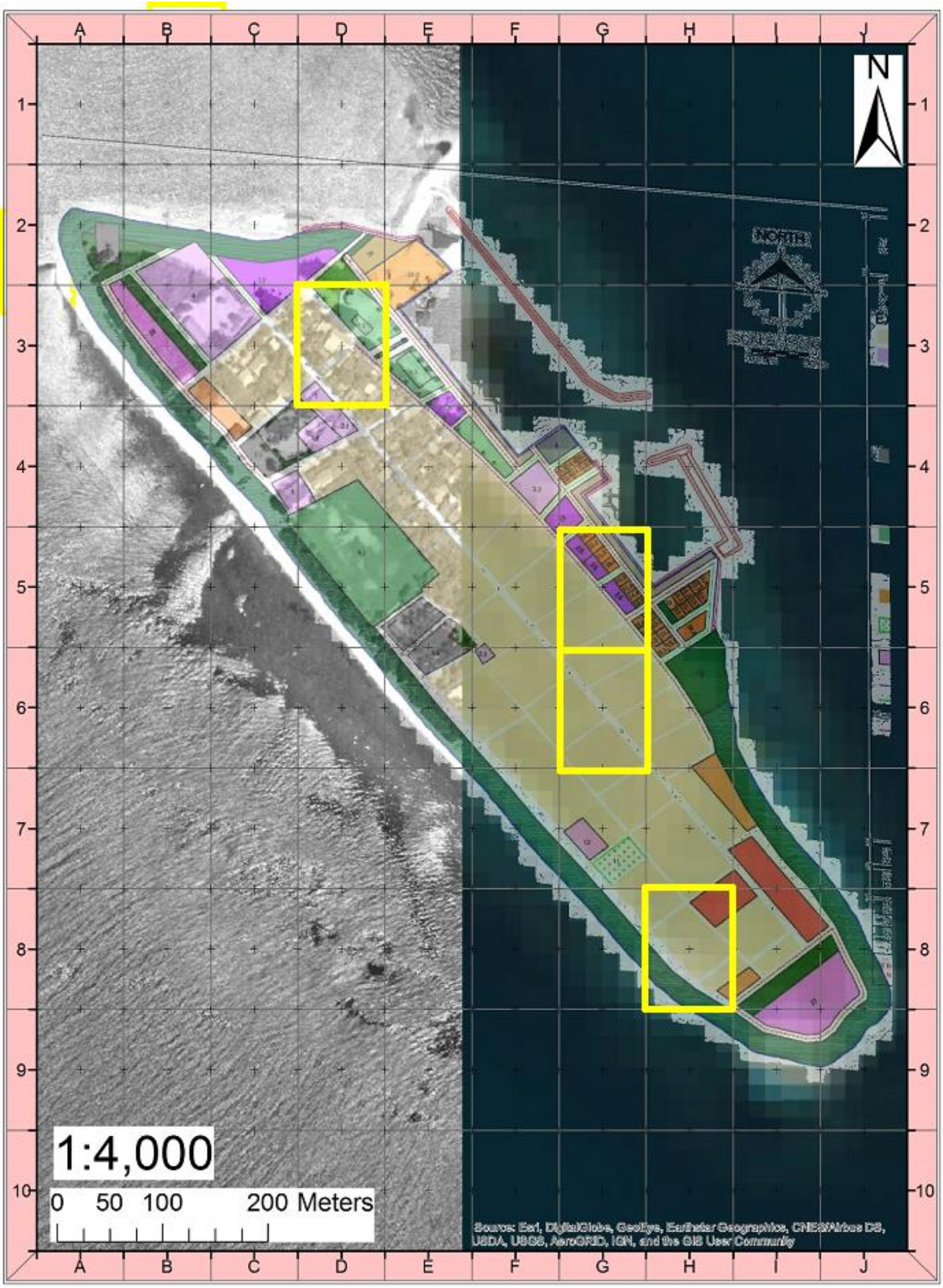
The interviewees from the islands were selected from the same cohort of participants selected for PCCAA. Focus group participants were requested to volunteer for interviews. PCCAA participants were briefed about the interview purpose and procedures during the first meeting and volunteers for interviews were selected. Each PCCAA group requested 2-3 volunteers for interviews. Generally, fewer women volunteered for interviews. Hence, the target was to recruit a minimum of two women volunteers, due to the difficulty of convincing women to take part, owing to cultural and religious restrictions within the local context. Pursuant to traditional settings of islands, a female sitting with a strange male interviewer is intimidating, as women seldom take part in such activities. A report by UNDP indicated that women bear “subtle and overt forms of subordination”, reinforced by heritage and Islamic traditions which influence their social conditioning (UNDP, 2011). Likewise, recruiting female participants was a huge challenge, even though lot of effort was undertaken in this study. Due to limitations in funding and to maintain consistency in interviews, I did not employ a female interviewer. Hence, I aimed to have a minimum of two female stakeholder interviews from each island. Expert interviewees working in the government and non-government organisations at a national level were selected purposively based on their portfolio, in the context of adaptation. Experts working in the ministry of Environment and Energy of the Maldives were consulted for selection of interviewees. Based on expert recommendation, officials working in different sections of the Ministry were chosen and interviewed. The Ministry officials were targeted as the Ministry is mandated to formulate and implement climate change polices, strategies, and projects. When choosing NGO interviewees, all four major national level NGOs working on environmental issues and climate change related projects were approached. Two NGOs responded and provided experts for the interviews.

Sampling of households for the questionnaire survey was carried out by adapting the compact segment sampling method given by Milligan, Njie, and Bennett (2004), as Maldivian Islands are homogenous and generally small in size and population. Drawing from Milligan et al. (2004), a GIS expert was consulted on sampling, and based on his expert views, maps were developed. On a land use map of the island, the wards were identified, and a grid of 1 to 10 on Y-axis and from A to J on the X-axis, was marked on each map (Figures 3.4 - 3.8) using Arc GIS 10.5. As the scale of maps used differed, households within each grid also differed. Using a mobile phone application for random number generation, two numbers were generated randomly by setting maximum number to 10 to select a grid. After generating two numbers randomly, a grid was chosen, and the centre of the grid was located. Once the location was confirmed, the survey enumerators began household surveying from that point. The enumerators were instructed to flip a pen and decide the direction to move forward from the point. All the households in these grids were targeted for the surveys. If a grid consisted of more than 20 households, the first 20 responsive households were chosen. However, as Fuvhmulah has a larger population, 30 households were targeted from each grid. In each island, four grids were selected. In the case of Hanimaadhoo (Figure 3.6), only one grid was chosen, as the grid (3, H) covered most households. From the centre of this grid, enumerators were asked to move in four directions North, South, East and West, and survey 20 households from each direction.

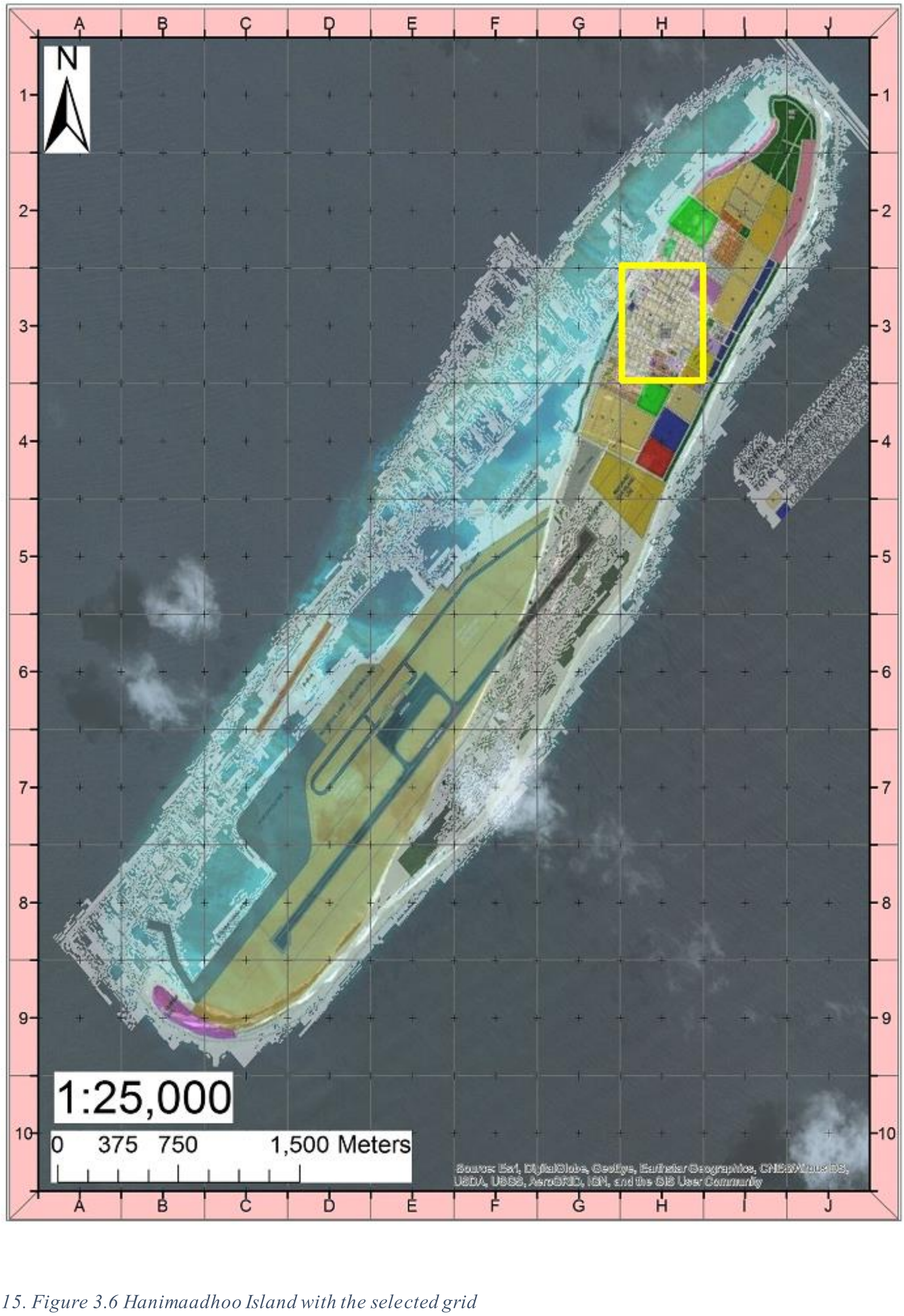
If a household refused to provide answers, or was no longer inhabited by people, the adjacent household was chosen. In rare cases, households in islands were abandoned or under construction, while some were converted for economic activities. Apart from a few households, most of the households responded to the surveys, resulting in a very high response rate. In most cases, the male or female head of the household was targeted, as the questions were mostly based on household demography, living conditions, and ability to cope and respond to climate related perturbations. On the island of Fuvahmulah, four clusters were selected from the seven wards designated officially, with two from each end of the island, and the rest combined into two additional segments. Figures 3.4 to 3.8 show the maps with the randomly selected grids for each island.



13. Figure 3.4 Bodufolhudoo island with randomly selected grids



14. Figure 3.5 Ukulhas Island with randomly selected grids



15. Figure 3.6 Hanimaadhoo Island with the selected grid

16. Figure 3.7 Vilufushi Island with randomly selected grids.

17. Figure 3.8 Fuvahmulah Island showing the grids selected randomly

3.7 Data collection

3.7.1 Biophysical data

Data on biophysical aspects were obtained from secondary sources, such as government documents, reports, and maps. Aerial photographs of case study islands for different time periods (1969, 2004, and 2009) were obtained from the Maldives Land and Survey Authority (MLSA). The aerial photographs were analysed using Arc GIS to explore urbanisation and changes in the islands over the past decades. In addition, Environmental Impact Assessment reports and other documents from the case study islands were obtained through the Environmental Protection Agency (EPA). The secondary sources were used to understand the changes in the biophysical environment of the islands over the past 20 years.

3.7.2 Data from PCCAA exercises

The PCCAA activities were conducted in the island council meeting room. The council staff organised the meetings and introduced the primary investigator to the groups. The group members' names, ages, and their main occupation were recorded, and participants were briefed about the aims and objectives of the research and the exercises. The consent from participants was obtained and time schedules for exercises were determined. In all case study islands, the same exercises were conducted with both male and female groups. At the beginning of exercises, a small presentation on future climate change predictions for the Maldives by end of 2100 was given. Participants were provided with aerial photographs of island, marker pens, and paper. All exercises were recorded on a digital voice recorder. Participants also carried out mapping and other exercises such as timelines and climate related perturbations faced by the community on paper. Table 3.4 provides details of the five PCCAA exercises undertaken on each island. The PCCAA focus group questions were presented in Appendix A1.

7. Table 3.4 Showing the PCCAA focus group exercises undertaken

Themes	Methods	Techniques	Data collected	Sample population
Biophysical and social features of islands.	Transect walk/ Mapping of island.	Drawing and discussions.	Key biophysical and social features of the island were marked on an aerial photograph, or a land use map of the island.	One male and one female group of 6 to 8 members from various economic and social backgrounds.
	Participatory mapping of community and areas affected.	Drawing and Discussions.	Mapping spatial characteristics of island, important features, such as boundaries, manmade and natural structures, areas vulnerable and exposed to climate change impacts, key infrastructure, and income generating sources.	
Severe weather-related climate change impacts.	Listing and ranking impacts.	Discussions.	Perceptions on effects of climate change impacts and ranking impacts according to severity and frequency.	
	Community history.	Discussions.	History of severe weather events and effects.	
	Timeline of events.	Drawing and discussions.	Discussion on time line of events and most critical weather extremes experienced within the last 10 years.	
Vulnerability to climate change impacts (vulnerable groups, areas, and capital).	Community mapping.	Drawing and discussions.	Mapping vulnerable locations, and identifying exposure and sensitivity of the areas to various impacts.	
	Severity of climate change impacts.	Discussions.	Effects of severe impacts at different levels of society and identifying the most vulnerable and highly impacted among the community.	
	Causal flow diagram.	Drawing and discussions.	Identifying the major causes and consequences of severe weather associated vulnerability. Identifying correlation between impacts and loss of assets.	
Adaptation of assets for impacts.	Listing and ranking.	Discussions.	Identifying assets critical for coping and importance of those assets for different levels of community. Identifying adaptive strategies by different groups and prioritising their importance for community.	
	Causal flow diagram.	Drawing and discussions.	Identifying impacts and consequences of severe weather on assets. Identifying strategies and solutions to adapt to severe weather.	
Institutional and governance mechanisms to cope with impacts.	Institutional Mapping.	Drawing and discussions.	Distinguish comparative importance of institutions, efficiency of institutions, role of different institutions in helping and coping. Integration and cohesion among institutions. Identify institutions within and outside of the community.	
	Listing and ranking.	Drawing and discussions.	Ranking of institutions by their importance to cope during extreme events.	

3.7.3 Interviews

Semi-structured interviews were conducted with volunteers self-selected from PCCAA focus groups, and with senior level government officials, and officials from non-governmental organisations involved in climate change adaptation. The interviewees were all adults of various age groups. Despite efforts to achieve a gender balance sample, male participants were more numerous than female, as recruiting female participants was a major challenge. Key informants selected from the islands represented different economic and social backgrounds. Interview questions pertained themes related to climate change adaptation capacity. Interviews lasted for 30 minutes on average, and were conducted according to the time and venues preferred by interviewees. Some interviews took place at the residence of interviewee, or at the council office. Interviews with officials were conducted in their respective workplaces during the working hours. Interviews for island key stakeholders were conducted in local Dhivehi language, and for government and NGO official, English language was used. Interviews were recorded on a digital voice recorder.

The interviews for island level key stakeholders began with a short introduction of the primary researcher and a brief about the research, followed by open ended questions for an in-depth understanding of participants' expert knowledge on adaptive capacity of the islands. General themes covered in all interviews included: (1) impact of climate related stimuli on the social and ecological aspects of the island; (2) most critical climate-related stimuli experienced in the island over the past 10 years; (3) coping strategies and assets, and resources at their disposal to cope with climate-related stimuli, as well as coping ability compared to the past and now; (4) changes in the island, which either enhance or impede their ability to cope; (5) factors which influence coping, how these factors are interrelated, and their causal effects; (6) assets at both island and household levels, which enhance their ability to cope; (7) experiences the respondents have had with regard to impacts on water and food security on the island; and (8) challenges faced in coping and responding to climate-related stimuli.

Interviews with officials working at policy level in the government institutions and non-government organisations began with a brief introduction about research, followed by open ended questions regarding government policies, programs, and strategies on adaptation. General themes covered in interviews included: (1) the organisation involvement in adaptation and projects being undertaken, and how projects are formulated and implemented; (2) objectives of the projects and success in implementation, as well as major obstacles in implementation; (3) effectiveness of government policies and strategies in adaptation, and how policies and strategies can be made more efficient; (4) how much people are aware of the most effective adaptation measures needed for their islands; and (5) should climate change be given political significance. (See Appendix A2 for key informant interview questions).

3.7.4 Household surveys

The surveys were administered by enumerators, through face to face questionnaires, which were filled out at the residence of the respondent. The questionnaire was targeted to the head of the household or his spouse. The survey included open ended and closed questions to investigate the demographic characteristics, socio-economic characteristics, climate change related stimuli experienced, their households' adaptation measures, and practices to respond to those stimuli, as well as perceptions on their capacity to adapt. The questions were adopted from other studies on adaptive capacity (Maldonado & Moreno-Sanchez, 2014; Moreno-Sánchez & Maldonado, 2013), and were modified to apply to a Maldivian context. A pilot survey was conducted in July 2015, on the island of Maafushi, by visiting 30 households to test the questionnaire. Based on the pilot survey, the survey questionnaire was revised, and some questions were modified to suit the local context. The number of surveys administered was determined to obtain the same percentage of households on each island based on national census data. In each island, the target was to cover a minimum of five to ten percent of households on each island. The survey forms used were attached in Appendix A3.

3.8 Data analyses

According to Greene et al. (1989), mixed data analysis in mixed research involving qualitative and quantitative methods is determined by the rationale and purpose for mixed analysis. Based on Greene et al. (1989), the purpose for the mixed qualitative and quantitative analyses undertaken in this research was to compare data by triangulation and for complementarity. Hence, results from the qualitative analysis were used to compare and complement the data from the quantitative analysis, to enhance and clarify research inferences. Following Johnson (2014), data analysis for this research involved multi-type, mixed analysis, whereby both qualitative and quantitative data were analysed separately. Data were then compared and integrated to derive meta-inferences.

Interview and focus group data were translated and transcribed by the primary researcher. Data analyses involved thematic analysis, and N-Vivo was used for managing the data. Thematic analysis involved identifying, organising, and interpreting themes, by categorising data into codes (Braun, Clarke, & Terry, 2014). Drawing from Elo and Kyngäs (2008), I used an integrated deductive coding approach, based on a coding matrix. The coding matrix used was adapted from Fereday and Muir-Cochrane (2006). Analysis involved inductive coding to derive codes which did not fit into the code structure, and deductive coding to derive codes which did fit within the code structure (Elo & Kyngäs, 2008). Finally, codes from all participants were clustered and interpreted to determine perceptions from participants. Results were presented in the form of tables, graphs and maps.

For analysing institutional and governance aspects I developed a matrix drawn from Engle and Lemos (2010), McConnell (2010), and Smith, Vogel, and Ill (2009), as provided in Table 5.

8. Table 3.5 Code structure related to institutional and governance aspects of adaptive capacity

Aim: **To explore the institutional and governance aspects of adaptive capacity and how they result in deficits and surpluses**	
Research Question: **What are the institutional and governance related variables which influence adaptive capacity of small islands?**	
Code structure	**Description of codes**
1- **Contextual factors (Smith et al., 2009)**	Climatic stimuli and governance and institutional factors which influence on how governance is prioritised
2. **Government priorities (Smith et al., 2009)**	How government prioritise climate change to develop strategies and policies to address climate change
3. **Political leadership (Smith et al., 2009)**	Leadership style from authoritarian to democratic styles
4. **Knowledge and information (Engle & Lemos, 2010)**	Accessibility to and capacity to obtain and utilise scientific information regarding climate change impacts
5. **Representation (Engle & Lemos, 2010)**	The level of representation and the established authority and accountability of the island council for the community
6. **Networks (Engle & Lemos, 2010)**	Different institutions at island level and their relationship with island council in coping and managing climate change impacts
7. **Resources (Engle & Lemos, 2010)**	Financial and human resources available for the council to address climate change impacts
8. **Interaction (Engle & Lemos, 2010)**	How various institutions and stake holders interact and the horizontal and vertical integration of institutions at distinct levels

For analysing socio-cognitive aspects of adaptive capacity I developed a coding matrix based on the socio-cognitive model of Grothmann and Patt (2005a). Though Grothmann and Patt (2005a) focused on individual adaptive capacity in their model, I extrapolated the concept to community level and is given below in Table 6.

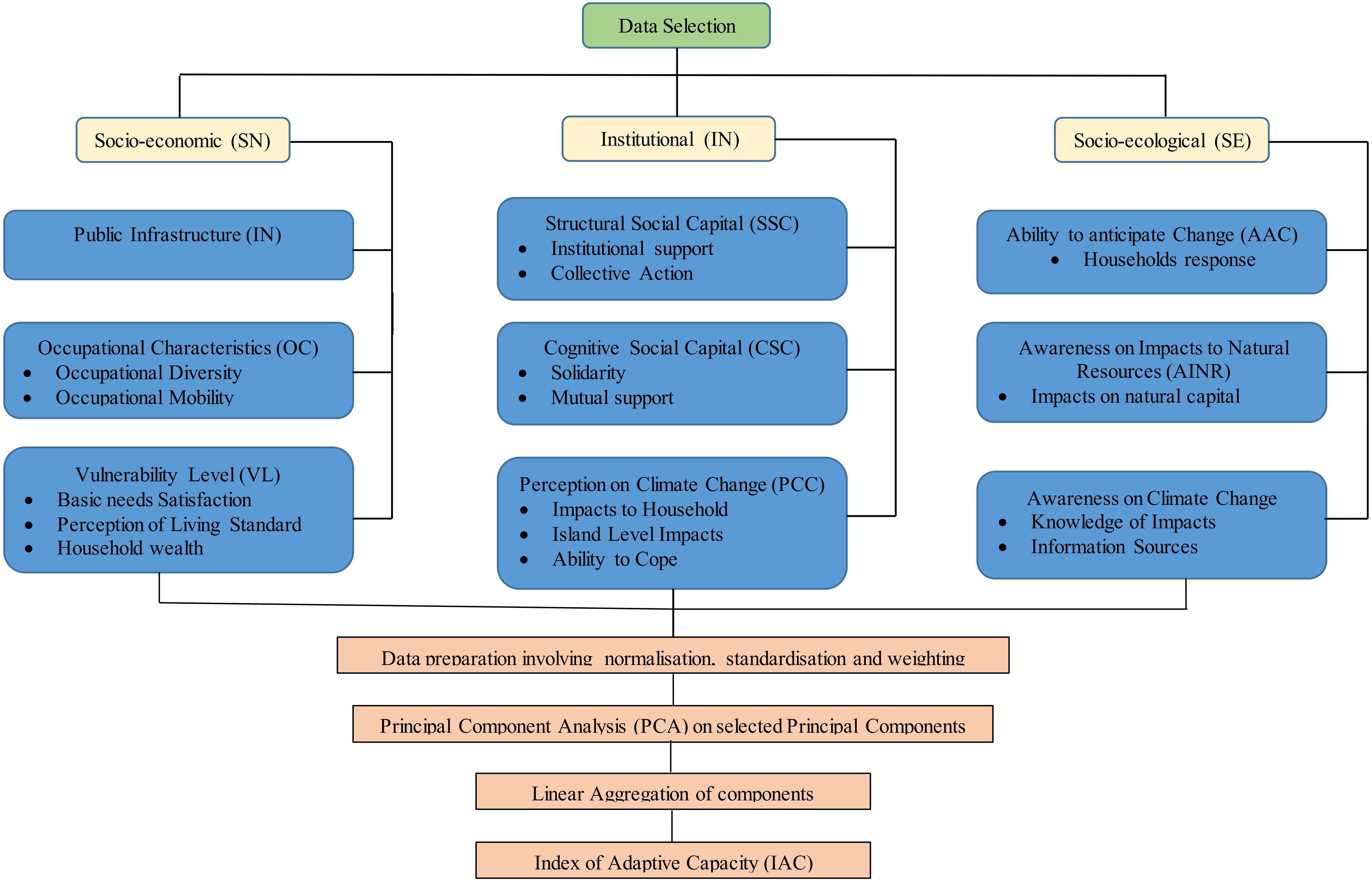
9. Table 3.6 Code structure related to socio-cognitive aspects of adaptive capacity based on Grothmann and Patt (2005a)

Aim: **To understand socio-cognitive determinants of adaptive capacity in island communities based on protection motivation theory.**	
Research Question: **How motivated are people for adaptation and which of these aspects influence adaptive capacity in islands?**	
Code structure	**Description of codes**
9. **Risk perception** a. **Perceived probability and severity**	People's belief of being exposed to climate related perturbations and their judgement of consequences based on extent of threats.
10. **Perceived Adaptive capacity** a. **Perceived community adaptation efficacy** b. **Perceived community efficacy** c. **Perceived adaptation costs**	a- Perception on how effective their actions are. b- Ability to cope or take relevant action to respond to impacts. c- Assumptions on costs incurred for adequate response.
11. **Maladaptation** a. **Fatalism** b. **Denial** c. **Wishful thinking**	Responses which cannot prevent damage or losses but can be emotionally satisfying. a- Events are inevitable and hence powerless to response. b- Denial of climate change threats and impacts. c- Beliefs and responses with no evidence or rationality.
12. **Adaptation intention**	Intention to respond and take necessary actions.
13. **Objective adaptive capacity**	Inherent ability pertinent to available resources in terms of finance, knowledge and community support mechanisms

Focus group responses were categorised according to the adaptive capacity themes explored through discussions. Analyses were carried out by following a thematic structure to describe the adaptive capacity of the islands studied. The results from PCCAA were themed into: community perceptions on climate variations and perturbations; vulnerability regarding each capital or dimension; adaptation strategies utilised to enhance resilience; and the role of institutions and organisations.

Quantitative analysis of household surveys was carried out to determine adaptive capacity based on the questionnaire. Several authors propose an index of adaptive capacity (IAC). For instance, Maldonado and Moreno-Sanchez (2014), and Moreno-Sánchez and Maldonado (2013) conducted adaptive capacity assessments using an index from 0 - 1. The IAC is a composite indicator, developed by combining different variables within the three key dimensions, socio-economic, institutional, and socio-ecological in to one scalar variable (Moreno-Sánchez & Maldonado, 2013). An IAC can determine the capacity to respond to impacts from a policy program, as well as the overall ability to cope and respond to climate change (Maldonado & Moreno-Sanchez, 2014). A composite indicator of adaptive capacity may be useful since a complex array of variables influence adaptive capacity, making a single indicator or few variables insufficient in determining the multidimensionality of adaptive capacity (Moreno-Sánchez & Maldonado, 2013). Figure 3.9 demonstrates an analytical process which can be utilised to derive IAC, using the three key dimensions, the indicators, and sub indicators. The figure was adapted from Moreno-Sánchez and Maldonado (2013), and Kotnik and Klun (2013).

An IAC with a scale from 0 - 1 could help in comparing the islands based on their ability to adapt and respond to future climate change. Even though developing an IAC was considered at the proposal stage of this research, shortcomings related to validity and reliability were later recognised. For instance, selecting indicating variables and weighting them is considered a major challenge (Hinkel, 2011). To enhance validity and reliability of results Categorical Principal Component Analysis was used in quantitative analysis instead of the proposed IAC and is described in detail in chapter seven of this thesis.



18. Figure 3.9 IAC analysis

3.9 Fieldwork Management

Field work in the Maldives was conducted over a period of approximately six months, from June to November 2015. Ethical approval to conduct field work was granted by the Human Research Ethics Committee of James Cook University on May 2015. Upon receiving the ethics approval, formal communication began with the Ministry of Environment and Energy of the Maldives to obtain official assistance. The Ministry provided support for approval for the field work and official communication with island councils. The Ministry informed island councils about the research and requested to aid during the field work phase.

A pilot study was conducted in July 2015, on the island of Himmafushi in the Kaafu Atoll of the Maldives. In the pilot study, it was found that people were hesitant to disclose certain information, as they believed that some questions may reveal their political views and occupation. Hence, the wording for questions on socio-economic status was changed. In addition, people were unable to commit sufficient time for PCCAA focus groups and interviews, due to ongoing celebrations of golden Jubilee of Maldives Independence. The pilot study was also disrupted due to Eid celebrations, and lack of support from island councils. However, PCCAA and interview protocols were piloted with a small group of five people, and 30 household surveys were conducted during the five days of the pilot study.

The field work in selected islands began in August 2015. The field work was constrained due to various activities related to celebration of Golden Jubilee of Independence, conducted between March and December 2015. Most of the islanders from the selected islands were engaged in various activities to celebrate Golden Jubilee of Independence. In addition, an outbreak of dengue occurred throughout the Maldives in August 2015 and, as a result, travelling to islands was halted for three weeks. During the field work, the Maldives was also faced with turbulent political events. For instance, the jailing of the former president on terrorism charges resulted in strikes throughout the Maldives. Additionally, the vice president was arrested and jailed for a suspected bomb explosion in the presidential yacht while the president was travelling with his family. This occurred while I was in the field collecting data. These events caused major constraints in conducting field work, as engaging people and motivating them to get involved in research activities became highly challenging.

Communication difficulties with the island councils, and the Ministry of Environment and Energy, also prompted major constraints during field work. Even though the Ministry informed the island councils of the work schedule and necessary arrangements required in advance, some councils disputed receiving any formal communication from the Ministry upon my arrival for field work. Thus, major delays in field work were experienced as organising PCCAA focus groups and interviews took longer than the original schedule planned for. Most communication barriers between the Councils and Ministry arose due to weak administrative procedures in the Island Councils, where fax machines or Electronic Information System were out of order. In addition, the lack of communication between the council members and council administrative staff resulted in challenges in planning and organising research activities.

Field work in all islands faced constraints and delays. Field work in Fuvahmulah Island, especially, was faced with more challenges. When I arrived to conduct the field work in Fuvahmulah, the islanders were engaged in a month-long sports competition. Thus, local people, including the council members, were engaged in the competition, resulting in inadequate support for conducting the field work. The male focus group could not be convened, even after repeated requests and changes in schedules, as people were heavily involved with the sports competition. After making three attempts, the male focus group was cancelled. In addition, the survey enumerators in Fuvahmulah were unable to complete the surveys within the given schedule. Surveys took longer due to the larger population size of Fuvahmulah. However, given the turbulent social and political environment and delays in schedules, all field work, except the PCCAA exercise for men, was completed. The household surveys of Fuvahmulah were completed in December 2015.

Delays in receiving secondary data (maps and aerial photographs) requested from the Maldives Land and Survey Authority (MLSA) also proved a major challenge. Even though the requested data does not include any sensitive information, the MLSA withheld some data and took more than four months to provide these data. The data obtained included some aerial photographs of islands. Despite the request for land use plans, the MLSA declined to provide the land use maps of the islands.

Lack of funding for field work was also a major constraint and I had to self-fund local travel and accommodation. Thus, field work was conducted within a tight budget and schedule. Survey assistants also could not be hired to assist in PCCAA and interviews. All interviews and PCCAA activities were conducted by the primary researcher and, hence, PCCAA had to be limited to two focus groups in each island.

While these challenges were faced during the field work, cooperation and responsiveness of participants was considered a major advantage. To accommodate for participants' own schedules, most focus groups were conducted in the late afternoon and evening, and flexibility was critical. Consequently, the field work was one of the most challenging aspects of this research.

3.10 Role of researcher

In this research, the primary investigator was responsible for the design, data collection and analyses, and reporting of the findings. In addition, the field work logistics, funding, and management were undertaken by the primary investigator. In any research, the primary investigator plays a crucial role to ensure the success of the research. Additionally, in phenomenological case study methodologies, the deep engagement of the researcher in exploring and understanding the findings is crucial (Creswell, 2013). On her website, Finlay (n.d. para 2) claims: "The challenge for phenomenological researchers is twofold: how to help participants express their world as directly as possible; and how to explicate these dimensions such that the lived world – the life world – is revealed". Therefore, by being the primary investigator in this research, it was critical for me to understand the island culture, traditions, and perceptions, and to build a good rapport with the participants. In my capacity as primary investigator, I was able to communicate with the participants and listen to them carefully as I'm a local fluent in Dhivehi. Similarly, the qualitative analysis also required critical reflexivity in analysing the participants' lived experiences, responses, and views (Davidson, 2012).

In island cultures, such as in the Pacific, ontology is more concerned with the meanings and relevance, since knowledge dichotomies do not exist in oral versus written; narrative versus definitive; or practical versus canonical; and fluid versus fixed (Thaman, 2003). Consequently, the ways of knowing and passing on knowledge in island cultures is strongly influenced by oral traditions (Thaman, 2003). Likewise, qualitative methods of enquiry in this research required listening to participants' views, opinions, and perceptions deeply and carefully. Hence, immersing deeply in, and switching between emic and etic perspectives, was critical. As the primary investigator, I engaged with the participants through focus groups and interviews as a learner, rather than a researcher with authoritative knowledge on adaptive capacity of islands.

3.11 Evaluation of research design

As this research was based on a mixed methodology, and involved qualitative and quantitative data collection and analysis, the problems with both quantitative and qualitative validity have to be addressed (Creswell, 2014). According to Onwuegbuzie and Johnson (2006), validity is a measure of the quality of the research, pertinent to research processes and inferences drawn. While validity in qualitative research is related to trustworthiness, quantitative researchers' determine validity by establishing strong cause and effect relationships (Onwuegbuzie, 2000; Onwuegbuzie & Johnson, 2006). Onwuegbuzie and Johnson (2006) used the term "legitimation", in order to determine an inclusive and descriptive term, relevant to validity for mixed methods pertaining to both qualitative and quantitative traditions. The authors based their claims on validity, following on from "inference quality", coined by Teddlie and Tashakkori (2003), who referred to validity as "design quality" and "interpretive rigour". To enhance validity, this study utilised the strategies given in sections below, as provided by Johnson (2014), and Onwuegbuzie and Johnson (2006).

3.11.1 Sample integration legitimation

The most critical aspect of mixed methods research is the extent to which strong meta-inferences and research outputs can be derived from mixed samples (Johnson, 2014). Hence, in this research we used statistically significant samples for quantitative data collection, while purposively sampling participants for qualitative data. Additionally, parallel samples were derived from the same population, in accordance with the research instrument's requirements.

3.11.2 Inside-outside legitimation

Inside-outside validity is based on the primary investigators' ability to understand, analyse, and present the subjective views of participants, while adhering to the investigator's own objective views (Onwuegbuzie & Johnson, 2006). The primary investigator of this study (I) was a Maldivian, who had prior knowledge of adaptive capacity to climate change in the local context of the Maldives. Hence, during the whole research process, I moved back and forth between the emic and etic viewpoints, to present and apply the emic and etic views purposively. Additionally, I took precautions by not being a sheer insider during field work, by avoiding immersing myself deeply as an insider. This allowed me to establish my objective views and rational judgements in interpreting the narratives of participants (Onwuegbuzie & Johnson, 2006). Additionally, the interpretations from participant narratives were peer reviewed by my supervisors, to ensure the etic view point established was valid and justified.

3.11.3 Paradigmatic mixing legitimation

In this research, I achieved philosophical validity by orientating the methodology within the world view of pluralism and dialectical pragmatism (Johnson, 2014; Onwuegbuzie & Johnson, 2006). In addition, the Theory of Islandness, based on relationships established by islanders with their environment, was incorporated to develop the theoretical views for the research. Theoretical and conceptual framing based on pragmatism and the Theory of Islandness were discussed in detail in Chapter two.

3.11.4 Commensurablity approximation legitimation

In mixed methods research, both qualitative and quantitative methods are employed and, therefore, the researcher needed to switch between a qualitative researcher perspective and a quantitative researcher perspective alternatively, before integrating both views (Johnson, 2014). Commensurability approximation for this study was established through critical analysis of qualitative and quantitative results without any bias towards an instrument or data set.

3.11.5 Socio Political legitimation

To ensure validity and reliability in mixed methods, research participants' responses, pertinent to their social and political views, had to be regarded as true and valid knowledge, based on their own worldviews (Johnson, 2014). In this study, focus group and interview participants shared varying political opinions and had different value judgements, which were all considered valid in uncovering the adaptive capacity in their island. Additionally, to gain a pluralistic perspective, secondary sources were used as a means of verification.

3.11.6 Multiple validities legitimation

Mixed methods involve both qualitative and quantitative components and, hence, all validities relevant to distinct research instruments had to be carefully established by addressing validity threats (Johnson, 2014). Careful designing of qualitative instruments minimises threats to construct validity and response validity (Houtkoop-Steenstra, 2000). In this study, the research questions for the semi-structured interviews and PCCAA exercises were carefully designed and piloted. Hence, the dimension of adaptive capacity of interest and questions used were interpreted by respondents as envisaged in the research problem. In addition, research interviews were conducted with a "localist approach" (Alvesson, 2003), considering the research interview as a social situation of an understanding relationship (Maxwell, 1992), and a complex social and organisational phenomenon, rather than a mere data tool (Dumay & Qu, 2011). Thus, both construct validity and response validity were achieved for the interviews and PCCAA exercises.

To ensure different perspectives obtained from informants' accounts were valid, key informants were selected by purposeful sampling. The main purpose of this research was not to find variations of adaptive capacity among different islands, but to find the adaptive capacity of "extreme or ideal cases" (Maxwell, 1992): and to discover which variables enhance adaptive capacity. Consequently, purposive sampling utilised in this research facilitated generalisation of findings to the particular case study island. The key informants who represented the PCCAA focus groups were also a mixed group, representing different social and economic backgrounds within the islands. Hence, the information obtained was rich and valid. However, the selection of participants was beyond the control of the primary investigator, as the choice of participants was down to the discretion of the island council. This may have resulted in biases in sampling.

In this study, credibility of qualitative data was ensured by triangulation of data from different methods and sources, such as PCCAA and interviews, as well as secondary sources. For transferability, five different case study islands were studied. To ensure dependability in qualitative data, we followed a similar case study protocol for each island, as stated by Yin (2009). For confirmability, the records of fieldwork and data were reviewed and discussed with advisors, as well as colleagues working in the field.

To establish external validity for quantitative sampling, random sampling was used, and statistical tests and sensitivity analysis were conducted. In addition, the survey was piloted and modified based on the results obtained from pilot study. Furthermore, the indicators obtained from the literature review (discussed in Chapter two) were adapted to fit in with the local context of the islands. The data obtained for indicators were normalised using a Min-Max approach (Maldonado & Moreno-Sanchez, 2014). Sensitivity tests were also conducted to validate the inferential statistics (Maldonado & Moreno-Sanchez, 2014).

To ensure reliability in surveys, all enumerators were given two hours of training on how to conduct the surveys, allowing them to thoroughly understand the questionnaire. In addition, the primary investigator accompanied enumerators at the beginning of surveys in each island. To ensure objectivity in surveys, enumerators were given clear instructions on how to approach and obtain responses from respondents of different ages, genders and socio-economic statuses. Hence, quantitative validity was ensured during the research process.

3.12 Limitations of research methods

In mixed methodology research, major limitations often arise in sampling and data analysis (Onwuegbuzie & Combs, 2011). Onwuegbuzie and Combs (2011) agreed that, when data analysis involves both quantitative and qualitative data, integrating results to a meaningful and robust research conclusion is challenging, and requires strong meta-inferences. In addition, triangulation of data from large quantitative samples and small qualitative samples can also be a major limitation, while qualitative and quantitative findings may result in disparities (Onwuegbuzie & Combs, 2011). For instance, in this study we used 10 focus groups and 37 interviews for the qualitative component, while we obtained 211 survey responses. However, careful delineation of results from each component in deriving meta-inferences reduced these limitations in achieving analytical generalisability. In conclusion this methodology was successfully demonstrated in this research while acknowledging these limitations.

Limitations also arose due to fatigue in working in the field, as research assistants could not be hired for PCCAA and interviews. Even though researcher fatigue may limit the richness of information obtained from qualitative components, consistency in data gathering was a huge advantage. In addition, using different methods required additional time in data collection, analysis, and deriving meta-inferences. Hence, mixed methods research is highly challenging, even though the approach is more reliable for the study of adaptive capacity of small islands.

3.13 Ethical considerations

The research involved interaction with local island communities, senior public servants, and NGO officials. Therefore, respect, integrity, and trust were adhered to in accordance with the ethical protocols and guidelines set by the Human Research Ethics Committee of James Cook University. In addition, confidentiality was maintained throughout, and informed consent was sought from all participants before administering the research instrument. All participants' names and other details were kept confidential, and all data were password protected. Scanned copies of raw data will be kept for five years in James Cook University's data repository. Also, during data collection, different political views expressed by participants were accepted without any prejudices. In addition, religious beliefs regarding climate change phenomena were given due consideration during PCCAA, household surveys, and interviews. As the Maldives is a Sunni Muslim nation, all research activities were conducted by giving due respect to prayer times and halting activities for prayer. In addition, research activities were ceased during the holy month of Ramadan. Consent forms used in field work and information sheets are provided in Appendix A4 and A5.

3.14 Summary

The purpose of this chapter was to provide the methodology utilised to explore and understand the adaptive capacity of islands of the Maldives to climate change. The chapter provided the mixed research methodology, based on analogue comparative case studies, conducted to study the phenomenon of adaptive capacity. The mixed methodology involved concurrent, parallel data collection using qualitative and quantitative methods. We used PCCAA involving focus groups, as well as key stakeholder interviews for qualitative data. The vital component for quantitative data was household surveys, conducted in each case study island, using questionnaires. Data analyses involved multi-type, mixed analysis. For qualitative data, thematic analysis involving deductive and inductive coding was used. For quantitative analysis, descriptive statistics, principal component analysis, and categorical principal component analysis was used. Data were presented using graphs, maps, and relationship diagrams.

The key findings from the research components have been divided into four main results chapters. The next chapter (Chapter four) is the first of such data chapters, and discusses the findings on governance and institutions in enhancing adaptive capacity of islands.

CHAPTER 4: MAJOR DETERMINANTS AND ENDOWMENTS OF GOVERNANCE AND INSTITUTIONS IN ENHANCING ADAPTIVE CAPACITY

Part of this chapter has been published in an edited book, as "Legacy of Authoritative Environmentalism and Path-Dependent Historic Institutionalism in the Climate Change Policy Dynamics of the Maldives": in Climate Change Research at Universities Addressing the Mitigation and Adaptation Challenges, edited by Walter Leal Filho (2017).

4.1 Adaptive capacity and governance

The aim of this chapter is to explore the relationship between institutions and governance, and climate change adaptive capacity of the islands of the Maldives. The chapter provides insights from senior level government officials and NGOs, as well as local community stakeholders, to understand national and local level governance and institutional mechanisms, and how the approaches and instruments influence adaptive capacity of islands. Data for this chapter were collected using document analysis, interviews and focus groups, analysed using thematic analysis. The chapter provides findings on how governance and institutional mechanisms are interlinked with adaptive capacity. The chapter concludes that path dependent historic institutionalism and authoritative environmentalism, as well as weak technical and institutional capacity impacts climate change governance in the Maldives, at both national and local levels.

The term governance refers to all means of societal elements where the public and private actors coordinate to resolve collective problems (Mayntz, 2007). Institutions describe both the agents or organisations as well as the scheme of rules or norms of conduct and can be formal, such as policies and laws or informal, such as traditional practices, beliefs and cultural values (Mayntz, 2007; Obeng & Agyenim, 2013). Hence, governance and institutions pertinent to climate change adaptation and mitigation are critical determinants of adaptive capacity (Engle & Lemos, 2010; Intergovernmental Panel on Climate Change, 2001; Lemos, Bell, Engle, Formiga-Johnsson, & Nelson, 2010). Governance and institutions are particularly significant for Small Island Developing States (SIDS) where people, their livelihoods, and ecosystems are highly threatened by global climate change (Scobie, 2016). Thus, SIDS must build and maintain efficient governance and institutional mechanisms to respond to climate change impacts.

Climate change governance and institutions broadly cover “cross-boundary, multi-level, multi-sectoral and multi actors” and are circumscribed by “longevity and uncertainty” of risks (Fröhlich & Knieling, 2013, p. 21). Consequently, climate change governance and institutions encompass a range of “values, policies and institutions” utilised by a society for collective interventions, by engaging with “economic, political, socio-cultural, and environmental affairs” through regulations, frameworks, organisational processes, and key actors (Engle & Lemos, 2010and Work, 2002, p.3; Lemos & Agrawal, 2006; Work, 2002, p. 3). Thus, in evaluating different levels and the multitude of sectors involved in governance and institutions, climate change governance is conceptualised in this chapter, as an embedded process of environmental governance (Fröhlich & Knieling, 2013).

Governance indicators pertaining to adaptive capacity include, “technical and financial capacity; institutional memory; and learning and participation, empowerment and accountability” (Eriksen, 2010, p. 81). Similarly, informal institutions and networks based on a community’s social capital are also crucial determinants of adaptive capacity, (Adgeret al., 2014). Consequently, well-organised and efficient manifestations of institutions and governance, reinforced by multi-level democratic decision making, are believed to enhance adaptive capacity (Engle & Lemos, 2010). It follows that, governance and institutions, underpinned by political dynamics within a country are essential for effective environmental governance and policy-making (Rivera-Batiz, 2002), considered as a “wicked policy problem” (Howes et al., 2013; Huitema et al., 2011). Therefore, understanding how governance and institutions influence the outcomes of climate change mitigation and adaptation policies is essential to determining adaptive capacity.

To date, there are few studies on the influence of governance and the role of institutional and socio-political dynamics on adaptation of vulnerable and marginalised communities (Eguavoen, Schulz, De Wit, Weisser, & Müller-Mahn, 2015). While environmental governance is influenced by special interest groups and the bargaining ability of people (Eguavoen et al., 2015), SIDS have been deficient in their approaches, as well as in their ability to plan and develop environmental governance instruments intended to enhance their adaptive capacity. For instance, democratic rule, considered to enhance environmental and climate change governance (Hochstetler, 2012; Lemos et al., 2010), is inadequate in many SIDS (De Souza, 2016). The consequence of these deficiencies in governance and institutions in SIDS strongly influences adaptive capacity in small islands. This chapter, therefore, set out to contribute to filling this gap in knowledge, by unpacking the effect of governance and institutions on adaptive capacity of the islands of the Maldives.

Before proceeding to the analysis, a detailed inquiry of governance and institutions in the Maldives will be elaborated on. This will include the contemporary governance structure and how governance and institutions have evolved, followed by findings and discussion of this chapter. The sections following on from this overview will investigate the influence of governance and institutions on adaptive capacity, based on the indicators described in the methodology chapter as: 1) democratic governance; 2) social capital and networks; 3) institutional cohesion; and 4) resource availability and distribution. The chapter concludes with a summary of findings on institutions and governance, and their influence on adaptive capacity of case study islands. The section 4.2 provides an elaborated account of how governance has evolved in the Maldives over the past decades based on document analysis.

4.2 Context of governance and institutions in shaping adaptive capacity in the Maldives

To understand the influence of governance and institutions that has shaped environmental governance in the Maldives, an analysis of how governance has evolved is essential. Like many of its South Asian neighbours, the Maldives was under British rule from 1887 to 1965; governed by monarchical self-rule until 1968. However, unlike other colonies in the region, the Maldives was a British Protectorate with no lucrative resources. Hence, obvious neglect and a lack of interest from Britain was evident in terms of influencing internal governance (Rasheed, 2014). Despite their lack of interest in internal affairs of the Maldives, British colonial rule brought a paradigm shift in two major provisions of statecraft in the Maldives. Firstly, the British devised the birth of the first written Constitution in 1932. Secondly, the British assisted in the establishment of an independent breakaway faction in the South of the Maldives, called the Suvaidive Republic in 1959 (Shafeeg, 2000). The short-lived Suvaidive Republic inherited a Westminster governance system, along with other institutional structures, cloned from Britain. However, the Suvaidive republic was dismantled within four years, resulting in the subsequent independence of the Maldives from Britain in 1965.

In 1968, under the authority of Prime Minster, Mr. Nasir, the Constitution was amended, transforming the Maldives from a constitutional monarchy to a republic for a second time. The new amended Constitution, adopted in 1968, made provisions for a one candidate system, whereby the parliament votes to select the single presidential candidate to be elected through public referendum (Shaheed & Upton, 2008). Ibrahim Nasir became the first president under this single candidate system in 1968 and ruled for two five-year terms. When Mr. Nasir decided to retire from politics in 1978, Maumoon Abdul Gayoom was selected by the parliament and he ruled for 30 years, under the single candidate system. During Gayoom's regime, economic development focused on elitism, and clientelism was reinforced without the engagement of civil society in major government policies (Carmen, Bruce, & Robert, 2015). Despite promoting rent seeking polity (Rasheed, 2014) and authoritarian rule, Gayoom was instrumental in bringing the climate change vulnerability of the Maldives to global attention.

Democratic transition of the Maldives materialised in 2008, with the adoption of a new Constitution, allowing the multiparty elections for the first time, which resulted in the end of the 30-year rule of Gayoom. However, this democratic transition was faced with major challenges in reforming governance, as envisaged in the new Constitution (Rasheed, 2014). Thus, a political crisis erupted, resulting in the controversial change of the newly elected government midway through its five-year term (Rasheed, 2014). The incumbent government came to power after winning the elections held in 2013. Throughout this long history, from pre-independence to post-independence, heavily centralised undemocratic governance inherited from the monarchical rule continued, until the new Constitution was adopted in 2008 (Rasheed, 2014). Rasheed (2014) believed that the past monarchical rule and the obsolescent nature of the 1968 Constitution constrained democratic governance from 1960s to 2000s. Hence, the Maldives was governed without democratic principles until major reforms began, owing to international pressure and political dissent since 2003 (Shaheed & Upton, 2008). Consequently, governance and institutions inherited from the past has led to path dependent historic institutionalism, where the historical institutions and their governance regime became embedded within the present governance system, weakening good governance in the Maldives (Rasheed, 2014).

From the time of monarchical rule till 2008, inhabited islands were governed through Island Chiefs, appointed by the highest political level. During the rule of the Monarch, Atoll Chiefs and Island Chiefs were appointed by the King to maintain order in the islands and to collect taxes. From the end of monarchical rule until 2008, Atoll and Island Chiefs were appointed through a cabinet level Ministry. Nonetheless, responsibilities and authorities were decisively added to their portfolio, based on the political preferences of the executive. Hence, the governance and institutional structure in the islands remained rudimentary, on the behest of centralised decisions made in the capital Malé. Consequently, decentralised governance and institutional mechanisms were constrained as a result of centralised control.

Owing to the legacy of path dependent historic institutionalism, the Maldives presents an example of an island state that remained under an authoritarian political regime for most of its history and continued with these traits, despite transitioning to a democratic state in 2008. Even though, the country has been a strong climate change advocate globally since the 1990s (Arnall & Kothari, 2015), attempts to address climate change in the country's environmental policies have remained unsuccessful for decades (Karthikheyan, 2010). Additionally, limited financial and technical capacity, transparency, accountability, and deficits in stakeholder participation have been considered as major factors hindering the successful implementation of climate change governance and environmental policies in the Maldives (Karthikheyan, 2010; Transparency Maldives, 2015).

Liberal democracies with democratic environmentalism demonstrate effective environmental policies and governance structures conducive for climate change adaptation and mitigation (Hochstetler, 2012). However, such democratic environmentalism is hampered by conflicts in opinion between various policy actors as a result of politicised public sentiments, values, and knowledge (McCright & Dunlap, 2011). Consequently, Authoritative Environmentalism (EA), distinct to authoritarian regimes, has emerged as a theory on environmental governance (Han, 2015). Gilley (2012) determined AE as an ideology based on the premise that the public is subjective and irrational compared to scientific constructs. Hence, justifying that only the state, their technocrats, and political elites are capable of developing and delivering environmental policy. Studies also indicate authoritarian environmental policies in countries with financial resources often succeed through political patronage and legitimacy (Beeson, 2010; Han, 2015), as is the case in China (Beeson, 2010; Gilley, 2012). In conclusion, analysing how AE influences the governance and institutions can provide understanding of interlinkages of environmental governance and adaptive capacity in the islands of the Maldives.

Although AE has been used to study the national context of climate change governance in countries, such as China and Korea (Beeson, 2010; Han, 2015), no literature exists on AE in the context of SIDS. Meanwhile, many SIDS at the forefront of climate change lack essential governance mechanisms such as: representation of vulnerable and marginalised island communities, knowledge, and accessibility; effective compliance and enforcement mechanisms; and rule of law and anti-corruption mechanisms (De Souza, 2016). In addition, many SIDS are plagued with political elitism dominating many aspects of their communities, owing to their small, closely knit communities, and high economic dependence (Benedict, 1966). Consequently, AE, in the context of SIDS, is critical to understand interlinkages of environmental governance and institutions with adaptive capacity.

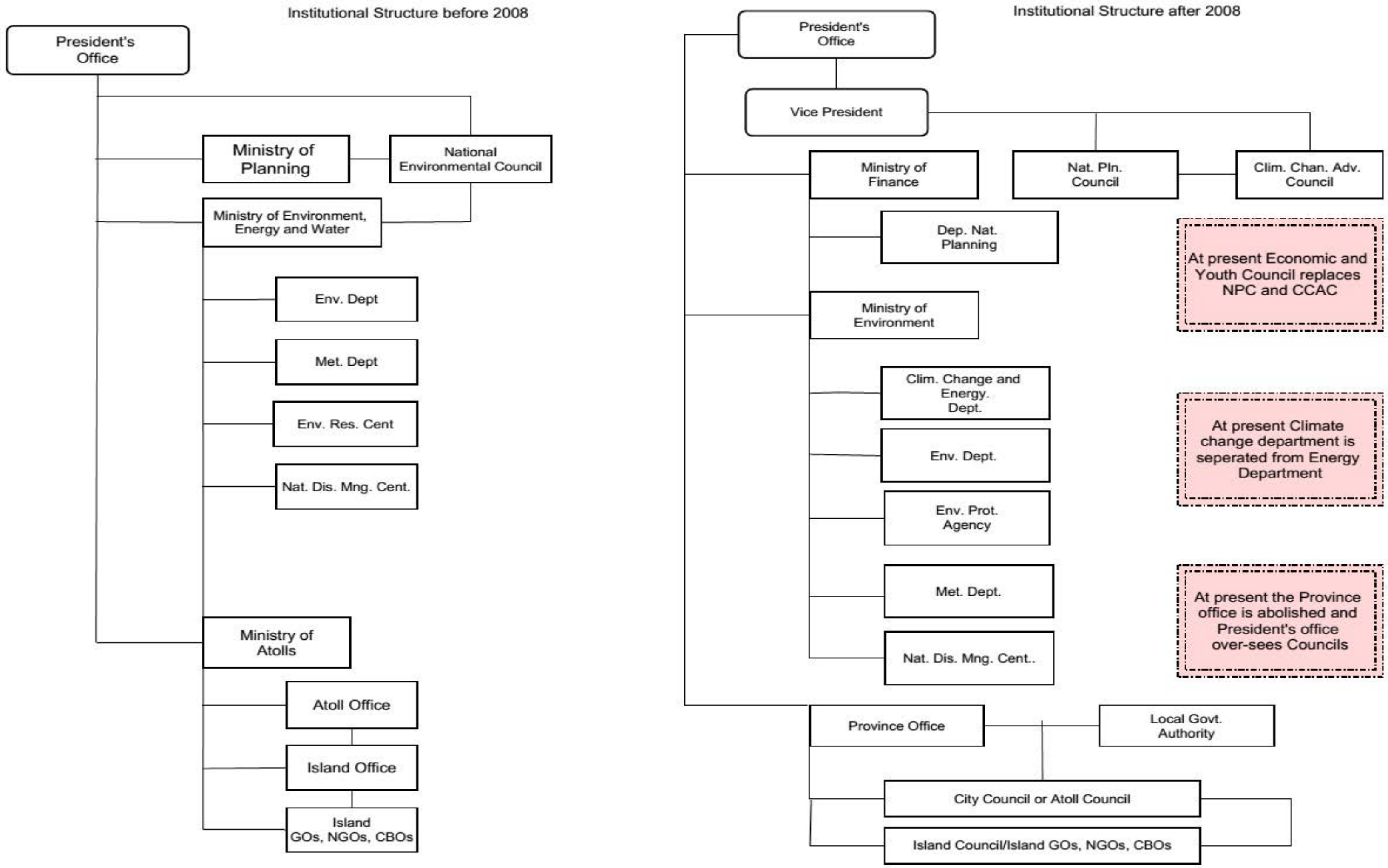
4.3 Environmental governance progressions of the Maldives at national level

The Maldives first established a statutory organisation for environmental governance in 1984, by creating the Environment Affairs Division within the Ministry of Home Affairs and Social Services (MEEW, 2007a). This division was then elevated to a cabinet-level ministry in 1988, and was called the Ministry of Planning and Environment. However, the ministry was buttressed with other cabinet portfolios until 2005. Following major reforms in the government in 2005, the ministry was separated from other portfolios, solely for environmental governance, and was called the Ministry of Environment, Energy, and Water (MEEW, 2007a). The ministry was governed under the guidance of the National Commission for the Protection of the Environment (NCPE), established in 1989, and remained functioning until 2008 (Figure 4.1).

Although the Environment Ministry was mandated with the formulation of environmental policy to achieve sustainable development (SACEP, 2002), policy formulation was based on authoritative environmentalism by a top-down approach. Additionally, the Environmental Protection and Preservation Act (1993) restricted the environmental policy-making of the Ministry, exclusively to areas which do not conflict with other laws or mandates of the other ministries (SACEP, 2002). This restriction was in place until the amendment of the act in 2014, giving full authority on environmental governance to the Environment Ministry. While the ministry had major legal and institutional constraints, there was no specific representation of the ministry at local administrative levels on the atolls or islands, as decentralised governance or organisational structures were lacking. Consequently, until now, integration of environmental policy at local level governance has been challenged by sectoral segregation and lack of participation from local communities. Thus, the Environment Ministry and environment related departments of other ministries continue to formulate and implement environmental policies at a centralised institutional level.

4.3.1 Environmental governance after the democratic changes of 2008

Until the Constitutional and democratic reforms began from 2003 onwards, major decisions regarding governance were at the discretion of the authoritarian President. However, with the adoption of the new Constitution in 2008, democratic governance was embraced. Consequently, environmental protection was also recognised as a constitutional right in the new Constitution of 2008, affirming; “The State has a fundamental duty to protect and preserve the natural environment, biodiversity, resources and beauty of the country for the benefit of present and future generations" (Article 22: Constitution of the Maldives, 2008). The new Constitution also emphasised the importance of environmental governance for the protection and preservation of the environment to assure inter and intra generational equity. Similarly, the constitution also stipulated establishing decentralised governance to ensure safe, healthy, and ecologically diverse environments for the enhancement of social and economic wellbeing of communities (UNICEF, 2013). Following these Constitutional reforms, institutional and governance mechanisms, and organisational structures were also reformed. For instance, a Civil Service Commission was established, allowing a non-political top-level civil servant, called the Permanent Secretary, to administer and manage the delivery of the mandate of the cabinet level ministries. This now withstanding, the major legal instrument for environmental governance, the EPP Act (1993), continues as a framework law, except for a few recent amendments. Meanwhile, a Decentralization Act, envisaging democratic decentralised governance pertinent to the Constitution, was enacted in 2010. Hence, an institutional foundation for environmental governance was laid with the democratic transition since 2008. Figure 4.1 shows the institutional arrangement of the government prior to 2008, and after the 2008 elections, and changes which occurred since 2013 in coloured boxes.



19. Figure 4.1 Showing the Institutional Arrangement of Environmental Governance

Following the democratic transition and subsequent elections of 2008, the Ministry of Housing, Environment, and Transport was established. This ministry was mandated with facilitation of environmental planning in major development sectors. However, managing the ministry buttressed with other portfolios became overwhelming, resulting in the separation of the transport sector from the ministry. Meanwhile, the government also brought major reforms in the organisational structure of the ministry and the mandate of the environment portfolio of the ministry. The changes included establishing a Climate Change Advisory Council (CCAC) as an oversight body for the Minister, under the authority of the Vice President and a National Planning Council (NPC) under the President (Figure 4.1). In addition, a Climate Change and Energy Department was established within the Environment Ministry. However, the institutional structure underwent major changes after the controversial change of the first democratically elected government in February 2012. From February 2012, the ministry was given only the environment governance mandate and the existing Climate Change and Energy Department was split into the Energy Department and the Climate Change Department (Figure 4.1). Additionally, the functions of CCAC were made obsolete.

After the 2013 elections, the new government abolished the CCAC. However, the Ministry of Environment and Energy and the Climate Change Department within the ministry was sustained as in the previous government (Figure 4.1). The new government established an Economic and Youth Council (EYC) and a Social Council (Figure 4.1). The EYC advises and approves major development projects and programs, including climate change adaptation projects. EYC's role in climate change governance is minimal, compared to the CCAC, which was established exclusively to oversee climate change governance (Khaleel, 2017). Consequently, the new government, elected in 2013, disregarded the top-level institutional emphasis for climate change governance which began in 2008.

Devolution of governance and decision making at the local island level was reiterated in the 2008 Constitution, and the Decentralization Act enacted in 2010. Despite this, path dependent historic institutionalism and undemocratic governance of the past continues to hinder effective decentralised governance. The government elected in 2008 established the Local Government Authority in 2010. Additionally, in February 2011, 188 island councils, 19 atoll councils, and two city councils were elected through a public referendum as envisaged in the Decentralization Act (UNICEF, 2013). The government also decentralised the country into seven provinces, with an institutional structure for each province. In each of the provinces, a health corporation, a utility corporation, and an education department were established

(UNICEF, 2013). Hence, the island councils could participate in the governance of health, education, and utility services at a local level in their own jurisdictions. However, governance of other sectors, such as the environment, continued to be centralised. None the less, The Strategic Action Plan, considered as the development framework of the country for the period of 2009-2013, postulated on decentralising environmental compliance and enforcement regime. Consequently, establishing an environmental management unit was initiated in the upper-north Province Office, and Addu City Council in the South. However, the decentralised institutionalisation of governance ended with the controversial change of government in February 2012 (UNICEF, 2013). Consequently, all decentralised institutions and administrative structures were reverted to central level, thereby terminating all provincial institutions (UNICEF, 2013).

4.3.2. Policy actors and their roles

The environmental governance arena in the Maldives spans from the national to local levels, with various institutional and administrative mechanisms. In the Maldives, the Climate Change Department under the Minister of Environment and Energy is the lead institution that coordinates climate change adaptation and mitigation policies, programs, and strategies. International donors and the UN agencies, such as the United Nations Development Program (UNDP), are also involved in managing various adaptation and mitigation programs and projects. International NGOs, such as the International Union for Conservation of Nature (IUCN), have also recently begun adaptation projects at national level. National level NGOs also conduct projects related to adaptation, while local, island level NGOs are involved in small scale projects, mainly dealing with awareness. At the local island level, island councils and city councils are crucial to projects carried out in their jurisdictions. The Decentralization Act (2010) mandates island councils to manage finances and to prepare five-year development plans for the islands, including urban planning and certain climate change adaptation measures, such as coastal protection. Nevertheless, due to the centralisation of finance and bureaucratic institutional statecraft at both central and local levels, none of these functions are effectively undertaken by local Councils until now. For instance, vertical coordination within the government is weak, and is especially evident between central government, and local island councils and other organisations in islands (Sovacool, 2012). In conclusion, the actors influencing climate change adaptation are challenged by inconsistent political decisions, and lack of technical and financial capacity in the implementation and coordination of major policies and strategies (Ahmed & Suphachalasai, 2014).

In this section a detailed account of manifestations of governance in the Maldives has been provided. The next part of this chapter presents the results of the analysis based on focus groups and key informant interviews, as well as thematic analysis of documents conducted using N-Vivo, as described in the methodology chapter.

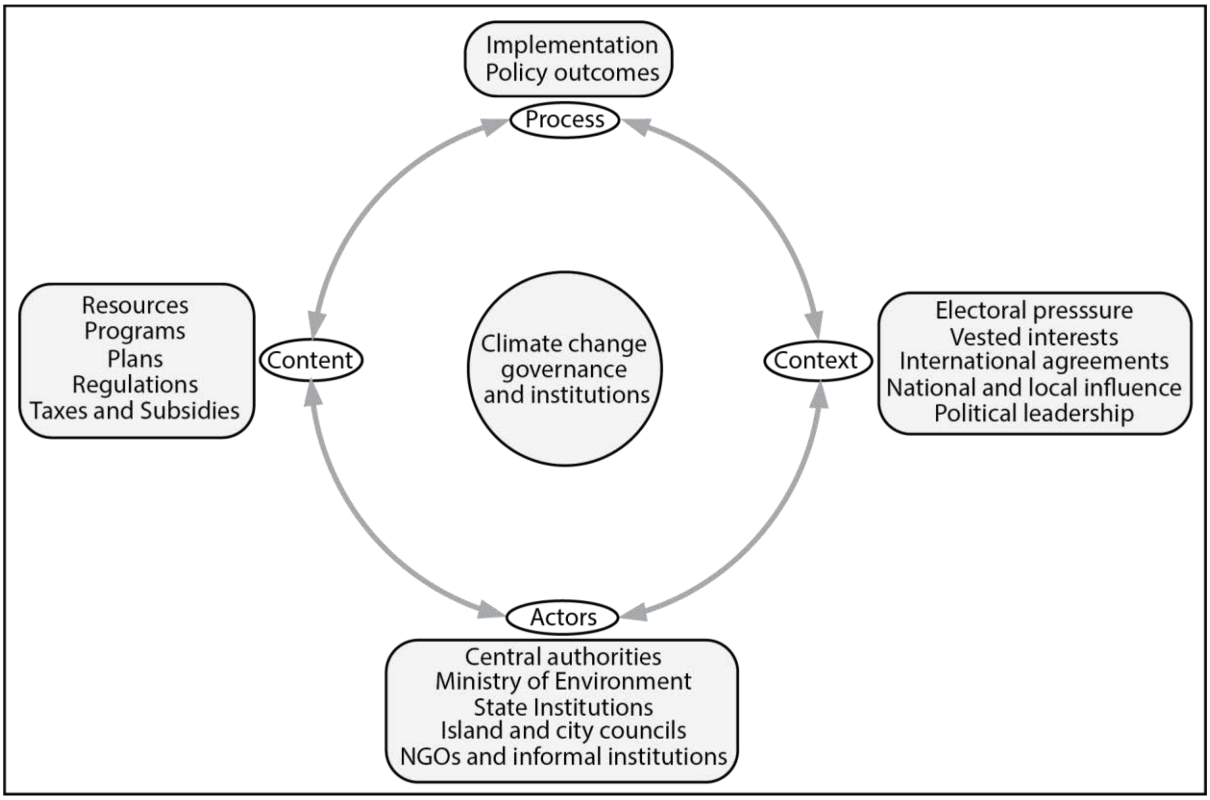
4.4. Analysis of governance and institutions at national level

Climate change is a contentious issue crosscutting all levels of governance; thus, active leadership from the highest political level of the government is essential (Ahmed & Suphachalasai, 2014). To understand climate change governance, various governance mechanisms and theories are evaluated in this chapter. Comparative policy analysis was considered particularly useful as a framework to understand the causes and effects relating to climate change policy and politics (Purdon, 2015). As the Maldives has undergone major political transformations over the past 25 years, comparative policy analysis can be utilised to explore and understand the context of authoritative environmentalism (AE) and path-dependent historic institutionalism in climate change governance and institutions.

Governance is a process whereby policy actors within the government recognise the importance of key issues and develop policy instruments through socio-political processes (Kingdon, 1993). The "three streams: problems, proposals and politics" are interlinked, allowing policy executives to reinforce their policies when contingencies for policies arise (Kingdon, 1993). Analyses of governance and institutions in this chapter are based on a conceptual framework adopted from Kingdon's (1993) model and literature from the three authors (Gilley, 2012; Han, 2015; McConnell, 2010). In this analysis, institutions are broadly defined as national and local level governance mechanisms and organisations which could influence adaptive capacity. Even though institutions differ from organisations or sectors, they can be considered as established arrangements of manifestations, mechanisms, processes, and interactions which link policies to people (Dovers, 1999).

The model in Figure 4.2 was used in this chapter to explore the environmental and climate change policy of the Maldives, and to frame a deductive coding structure for qualitative data analysis via thematic analysis, as described in the methodology chapter (Chapter three). This model demonstrates that contextual factors stemming from the climate change issues determine the environmentalism philosophy, which in turn determines how the government prioritises and delivers environmental policies. The framework also illustrates that the implementation and outcomes of the policies are profoundly influenced by the state and their political elites.

The conceptual framework (Figure 4.2) suggests policy-making is an interlinked, holistic process revolving around path-dependent historic institutionalism and AE.



20. Figure 4.2 Showing the Conceptual Framework of policy making

4.4.1 Contextual factors and government priorities from the past to the present

Findings from the document analysis indicated the contextual factors that influenced the prioritising of climate change from 1990-2008 were the fragile nature of the islands, and the crucial significance of the natural environment in sustaining the two major industries, namely tourism and fisheries. Estimates showed that the Maldives generated US$4 billion from the tourism sector in the period between 2001 and 2009 (Rasheed, 2014). Hence, the major contextual factor which influenced government policies was the likely future impacts to tourism and fisheries, due to climate change (MPHRE (Ministry of Planning Human Resources and Environment), 1990). This may have been influenced by the rent-seeking political mentality arising from the historic institutionalism's path dependency (Rasheed, 2014). Consequently, major policies highlighted the importance of preserving and protecting the environment for sustainable development by sustaining major economic activities.

Contextual factors that influenced policy also included the 1987 flooding in Malé. Following this disaster, international aid was critical, and President Gayoom was compelled to draw world attention on the vulnerability of small islands (MPHRE, 1990). Subsequently, the Maldives ratified the UNFCCC and negotiated for special recognition of the vulnerability of small islands at the UN Earth Summit of 1992 (MHAHE, 2001). Dual policies of formulating and enacting environmental legislations and participation in international platforms (MPHRE, 1990), were prioritised as the major policy for environmental governance from 1991 onwards. Additionally, the government also conducted climate change impact modelling for key islands based on the findings from the Inter-Governmental Panel on Climate Change (IPCC) Assessment Reports (MPHRE, 1990). In addition, institutional capacity development for the environment sector was emphasised, as human resources and technical capacity were limited. Despite this, compared to efforts at the international level, local level actions were considered inadequate. On the discrepancies of local and international efforts, one NGO interviewee argued:

> *Gayoom was very vocal internationally, but locally there were few steps taken. (NGO 01)*

Pleading to the international community to assist in adaptation programs was stressed in the 1990s, considering the negligible contribution of the Maldives to greenhouse gas emissions. For instance, Gayoom stated the "Maldives urges industrialized nations to give financial and technological assistance to States which are under immediate threat" (Speech given in the Convention on the Sea and Environment, Italy, 1991). Consequently, adaptation was significantly emphasised during this era. For instance, a Safer Island Strategy (SIS) was developed in 2005. This policy was developed to address the severe impacts from the 2004 Indian Ocean Tsunami and was aimed at developing selected islands with proper, hard engineering adaptation measures, to relocate people living in vulnerable islands. However, this policy became futile, as forced relocation of entire populations was highly controversial and undemocratic (Naseem, 2016). Subsequently, the government elected in 2008 replaced this policy and shifted to a policy and strategy to connect islands, via a nationwide transport network. The aim of this policy was to instigate voluntary migration instead of forced resettlement in safer lands.

Contextual factors influencing policy formulation changed between 2008 and 2012, due to democratic transition and consequent democratisation. Strong emphasis was given to decentralisation, policies based on utilising the potential of the country, and a major shift from rent-seeking to a modern tax system. Additionally, the National Sustainable Development Strategy of 2009 reiterated making the entire nation carbon neutral by 2020. Thus, the government prioritised mitigation and developing the country's renewable energy sector. The government also re-evaluated hard engineering adaptation measures for coastal protection and began seeking other alternatives, while population consolidation policy, popularised in the period of 1990-2008, was considered incompatible with democracy. The Population Consolidation Policy was first stated in the Fifth National Development Plan (1997-200) and later made into a strategy in the Sixth National Development Plan (2001-2005), to address the issues related to diseconomies of scale arising because of spatial dispersion of populations (Bertaud, 2002). Population Consolidation was later extended by integrating with the Safer Islands Strategy developed in 2005. While the Population Consolidation as an adaptation was disregarded, the government initiated a major mitigation policy by placing an emphasis on a Carbon Neutral Policy. An NGO official interviewed praised the environmental governance changes after 2008, and believed that Carbon Neutral Policy was an important instrument for public involvement and awareness on climate change. As one interviewee put it:

> *His [president Nasheed's] carbon neutrality plan was a huge wakeup call for Maldivians, especially because people who denied climate change started to question about it and started to talk about it. (NGO 01)*

During the interim period between 2012 and 2013, after the controversial change of the elected government, there were not any major policy reversals, but the Carbon Neutral Policy was detracted in favour of making the entire Maldives a marine reserve by 2017. On the contrary, a paradigm shift took place when Yameen became president by winning the 2013 elections. This shift occurred with the reversal of the carbon neutral policy to a low carbon strategy and advancement of population consolidation, which had been retracted from 2008 onwards (Naseem, 2016). Additionally, a developmentalism approach, based on East Asia's developmental states, such as Singapore, became aspirational (Naseem, 2016). This philosophy is based on the political context of pursuing economic goals through governance of resources, markets, and industries, as a means of achieving national security and economic prestige (Kim, 2016). Hence, the incumbent government prioritised economic policies. Talking about this issue, an NGO informant said:

> *When I was meeting, as part of young people [civil society] who met Yameen during his [presidential] campaign, he told his supporters he is an economist and not an environmentalist. (NGO 01)*

A lack of commitment from the current government on climate change adaptation, at a local level, was also highlighted by a government official respondent, who declared:

> *In the international arena, Maldives is very loud and played key roles in climate change adaptation and resilience. But unfortunately, at home, at local level we don't see that much. (GOV 04)*

The findings from document analysis revealed that contextual factors influencing climate change policy between 1990 and 2008 were the vulnerability of the country to climate change, and the threat to critical coastal marine resources. Due to the importance of the environment for development, environmentalism was framed to achieve sustainable development in this period. Such framing may have been influenced by foreign experts, advising the government during this period, or the rent-seeking attitude of the government. Hence, authoritative environmentalism was the major policy philosophy during the 1990-2008 period. Although vulnerability was contextualised between 2008 and 2012, emphasis on mitigation was more evident compared to adaptation. Consequently, showcasing the potential of the nation to lead by example was the major goal from 2008-2012. Simultaneously, consideration of the role of public consultation and democratic governance was also emphasised. Due to the democratic values enshrined in the new Constitution, democratic principles and values became a huge priority, resulting in the promotion of democratic environmentalism. However, the global financial crisis of 2009 also demanded economic rationalism in major policy decisions. Hence, reducing dependency on imported fuels became a major contextual factor motivating aspirations for a carbon neutral policy. These findings indicate that environmental philosophies are embedded within the wider political and economic policies of the different governments.

4.4.2 Policy outcomes from the past to the present

Although addressing climate change at both international and national levels was prioritised, achievements in international advocacy were more effective from 1990-2008. Themes emerging from data extracts on policy outcomes show some critical achievements between 1990 and 2008. The SOE (MPHRE, 1994) highlighted the establishment of an Environment Research Unit in 1990, the enactment of the Environmental Protection and Preservation Act (1994), and installation of tide gauges to monitor the sea level. Despite the enactment of an

Environment Law and a Research Centre, the lack of capacity was a major hindrance in achieving policy targets. Although an Environmental Impact Assessment (EIA) was mandated by the Environment Law, 74 coastal development projects were carried out between 2001-2004, without EIA (UNEP, 2005). Additionally, there was a failure of environmental monitoring and evaluation, as the government lacked trained people to effectively monitor and implement policies (UNEP, 2005).

Achievements in adaptation included integrated coastal zone management, and measures implemented to safeguard new settlements built on islands (MHAHE, 1999). The SOE reiterated successes from legal instruments, such as banning of coral use in construction of resorts, and reducing the import duty for construction materials (MHAHE, 2001) . In addition, commencement of solar energy projects and conservation of freshwater in islands were considered as major achievements, garnered through economic instruments. Between 1990 and 2008, several policy documents were generated; nevertheless, the status of policy implementation has never been monitored or assessed (UNEP, 2005). Furthermore, segregated policies formulated by different ministries were never integrated, while lack of capacity at island levels was a major challenge (UNEP, 2005). Hence, policy implementation did not fully achieve the aims and objectives envisaged for sustainable development during the 1990 to 2008 period.

Policy implementation and outcomes, during the period of 2008 to 2012, included major successes in mitigation through transformation of the energy sector and implementing renewable energy projects and market instruments to promote renewable energy. Additionally, decentralisation of environmental governance was initiated through local island councils. The government also established the Climate Change and Energy Department within the Environment Ministry in 2008. Additionally, the CCAC prioritised climate change issues at the highest level of the government. Unfortunately, the government collapsed, due to controversial political changes.

Post-2012 saw the historic Paris Agreement of 2015, where the Maldives played a crucial role as the chair of the Alliance of Small Island States (AOSIS). The government also began implementing several renewable energy projects through donor funding. Also, coastal protection for thirteen islands started, and seven islands were reclaimed by the end of 2015 (Fathih, 2016). However, one of the critical limitations in policy implementation was the integration of climate change adaptation and resilience in development projects undertaken by the government, and was noted by one government official interviewed, who said:

> *Even in the critical projects like Safer Island Strategy, reclamation projects and coastal protection, climate change adaptation or resilience is not built in the design or built phases of projects of Ministry of Housing and Infrastructure. It is only implemented in the donor funded projects. (GOV 04)*

Hence, most development projects are not purposefully designed to build adaptive capacity. In addition, due to lack of evidence-based data and local research, most adaptation projects and programs are heavily influenced by donors. Most donor funded projects face challenges in implementation, as stated by one government official:

> *Sometimes the way some of the donors' plan to implement the projects are not efficient, but I think overall, we benefit a lot from those projects. (GOV 01)*

Most officials from government and NGOs reiterated the lack of capacity in achieving the targets set in major development projects. For example, one government official mentioned:

> *I would say most of the projects we implement we are getting good results. But still we need improvements, I would say mainly the shortcomings are due to limited capacity. (GOV 01)*

In addition to the lack of capacity, representation of affected people in policy making is also considered inadequate (Transparency Maldives, 2015). Although most government documents analysed mentioned wide stakeholder consultation, such as is in the case in the NAPA (MEEW, 2007b) and MCCPF (MEE, 2016a), representation of affected people living on islands and their views is inadequate. An NGO official said regarding the MCCPF document:

> *I don't think it was done with consultation with the public… Public consultation was not enough. (NGO1)*

In addition to this lack of representation, inadequate knowledge and awareness of people regarding the most appropriate adaptation measures for their islands is also a major impediment to adaptive capacity. Even though traditional environmental knowledge is critical, most adaptation measures, such as coastal protection, roads, or other infrastructure, are widely regarded as development. Hence, most island communities demand infrastructure that is not necessarily designed to suit their local island conditions. For instance, an NGO official interviewed commented:

> *They are not aware. Usually what they will ask is for something they see on another island. ...They will want the same. ... Also, during the EIA process, not much opportunity [for locals] to give suggestions. (NGO2)*

Major environmental policies advanced to address climate change, during this era were the population consolidation and Safer Island Strategy adopted prior to 2008, and the carbon neutral policy adopted after 2008. While the carbon neutral policy was upheld from February 2012 to 2013, another major policy on making the entire nation a biosphere reserve was enacted. After the 2013 elections, the elected government abolished the carbon neutral policy, while maintaining and reinforcing population consolidation and biosphere reserve implementation. As a new policy, leaning away from climate change adaptation and mitigation, the government have embarked on an agenda for oil exploration and infrastructure development without mainstreaming adaptation.

4.4.3 Political Leadership from the past to the present

Three different eras in the political context and climate change policy were examined. This included the approach, environmentalism, and policy outcomes, which are summarised in Table 4.1.

10. Table 4.1 Environmental philosophies and policy instruments and policy outcomes from 1990 to 2015

Policy and governance	***1990 - 2008***	***2008 - February 2012***	***February 2012 - 2015***
Philosophy of environmentalism	Authoritative environmentalism framed as sustainable development	Democratic Environmentalism framed with economic rationalism	Authoritative environmentalism framed with developmentalism
Constitutional status of environmental issues	Constitution did not recognise environmental protection	Articulated the duty of State to protect and preserve natural environment and all resources for future generations	Constitution of 2008 continues
Major environmental policies, strategies and action plans relevant to climate change	*First National Environmental Action plan (1990) *Second National Environmental Action plan (1999) National Development Plans (once every five years). National Solid Waste Management Policy Framework (2004) *National Implementation Strategy for Addressing Climate Change (2001) *National Adaptation plan of Action (2007) *Sate of the Environment Reports (1994, 2001, 2002, 2004) National Biodiversity Strategy and Action Plan Vision 2020 (1999) sand National Development Plan *First National Communication of Maldives to UNFCC (2001) Safer Island Strategy (2006)	*Third National Environmental Action Plan (2009) "Aneh Dhivehi Raajje" The Strategic Action Plan 2008 *National Strategy for Sustainable Development Maldives National Energy Policy and Strategy *State of the Environment (2011)	Waste Management Policy (2015) Maldives Intended Nationally Determined Contribution (2015) *Maldives Climate Change Policy Framework (2015) Maldives as a Biosphere Reserve – Implementation Plan 2013 – 2017 (2012)
Institutions for environment policy implementation	Ministry of Environment 1988, an Environment Research Unit (1990) later changed to Environment Research Center Established National Commission for the Protection of Environment in 1989, discontinued after 2007 Established the National Disaster Management Center in 2005	Ministry of Environment integrated with other statutory bodies Established the Environmental Protection Agency (2008) Established Climate Change and Energy Department (2009) within the Environment Ministry	Ministry of Environment as an independent statutory body with the Climate Change Department (2012) and Energy Department (2012) Ministry of Fisheries and Agriculture Ministry of Tourism Ministry of Health
Environmental laws and regulations enacted	Environment Protection and Preservation Act (1993) Environmental Impact Assessment (EIA) Regulations (2007) Regulation on Protection and Conservation of Environment in the Tourism Industry (1999) The Fisheries Act of the Maldives (1987) Tourism Act of Maldives (1999) Banning use of coral for construction Law on Flora of inhabited islands (1998)	HCFC Regulation (Reg. no. 2010/R-19) Regulation on Environmental Liabilities (2012)	Waste Management Regulation (Regulation No: 2013/R-58) Environmental Impact Assessment Regulations (2012)
Priorities of government	To preserve and protect environmental resources for sustainable development	To become carbon neutral and to build resilient communities through environmental stewardship and sustainable development	To achieve economic prosperity and to protect and preserve environment

(*) ***Indicates the documents analyzed in this study***

The autocratic rule, from 1978 to 2008, lacked emphasis on human rights and good governance in the Maldives (Bonnerjee, 2014). During this period, ruled by president Gayoom, climate change policy was largely governed by strong political will and initiatives undertaken at the presidential level, with minimal involvement of the public (Carmen, Glavovic, & Robert, 2015). Consequently, during the period of 1990-2008, AE was adopted. For instance, the policies of population consolidation, safer island strategy, and infrastructure development were formulated by technocrats, dominated by direct political influence. Gayoom's government showcased highly liberal politics on international platforms, while ruling with a heavy hand (BHRC, 2015), undermining democracy and good governance.

Gayoom was educated in Egypt and, therefore, utilised his experience in middle eastern politics, and used the Islamic rule of Hosnei Mubarak as a model (Mulberry, 2012). Gayoom also gained political exposure and experience in working in the government of Ibrahim Nasir as a cabinet minister in 1977 (Shaheed & Upton, 2008). Hence, he had in depth knowledge of local and international politics, allowing him to reinforce his autocratic rule, especially through international support (Shaheed & Upton, 2008). Gayoom has been acknowledged for utilising the opportunities in the international fora to lobby rich countries on the challenges of climate change in the Maldives. Regarding past leadership, a government official commented:

> *I would say we had stronger leadership in the 90s and 2000s and from 2008 till 2012. (GOV2)*

Consequently, during the period between 1990-2008, the Maldives was known to the West as a beautiful holiday destination whose existence was threatened due to global climate change impacts (Shaheed & Upton, 2008).

In 2008, Gayoom was succeeded by Nasheed, a journalist educated in Britain (Gray & Foran, 2015), with a wide range of political exposure in Westminster Democracy. Nasheed not only became a champion of democracy after winning the election, but also became a champion of climate change, both nationally and internationally (Gray & Foran, 2015). Nasheed brought a paradigm shift in the framing of climate change by changing the discourse of the Maldives from a victim to an accomplished nation (Gray & Foran, 2015). In his speech given at the Climate Vulnerable Forum in November 2009, he stated, "In the Maldives, we want to focus less on our plight; and more on our potential" and for the first time, the Maldives began moving away from decades of advocacy based on victims of western industrialisation. While demonstrating strong leadership internationally, Nasheed was also instrumental in local level advocacy and awareness through his famous under water cabinet meeting and carbon neutral pledge (Gray & Foran, 2015). Nasheed's democratic principles also made him adopt democracy and good governance as key elements in climate change politics. In an interview on a documentary film on climate change, Nasheed stated, "Traditionally, we have always thought or highlighted saying that adaptation represents physical structures, revetments, embankments, breakwaters and so on. But we feel that one of the biggest, the most important adaptation issue [sic] is good governance. And therefore, consolidating democracy is very important for adaptation" (Television for Education Asia Pacific, 2009).

Following the 2012 political turmoil, and the controversial resignation of Nasheed, his vice-president Waheed took over the country in February 2012. Although policy reversals are common with such changes of regimes in developing countries (Steinberg, 2012), this change did not undergo major policy reversals. Hence, during the aftermath of the political crisis of 2012, the Environment Ministry continued with existing policies.

The incumbent President, Yameen, is an economist educated in Lebanon and the U.S., with a strong background in economic policies. Yameen worked in the trade and economic sector for many years as a cabinet minister during his brother Gayoom's 30-year rule. Hence, his government came with major policies for economic development. One government official mentioned with frustration:

> *The current government is not very much thinking of climate change. Because the current government's agenda is pretty much focused on economic growth. (GOV 02)*

The heavy focus of Yameen's government on economic development has undermined the climate change leadership the Maldives enjoyed in the past decades. As such, the current government of the Maldives is regarded as a laggard in climate change leadership, especially at the local level. Regarding the lack of political commitment, an NGO official interviewed said:

> *I don't think we have that much commitment when it comes to policy makers… I have not seen the president of the Maldives taking a personal stand, addressing climate change. (NGO 01)*

Although political leadership is weak, the professional bureaucracy within the ministry is considered critical for climate change policy implementation. The civil servants working in Climate Change Department within the Environment Ministry are critical in pushing the climate change agenda and in moving the nation forward. An interviewed NGO official commented in praise and said:

> *There are technical people within the Ministry of Environment who would want to see a good climate change paper and document, and want to see something going forward. (NGO1)*

Political leadership over the past 25 years reveals authoritative environmentalism as a dominating ideology of the government up to 2008. While democratic environmentalism and economic rationalism were strengthened from 2008 to 2012, authoritative and developmental perspectives have been established since 2013. While Gayoom and Nasheed were highly vocal in their advocacy, the incumbent president Yamin has not taken the climate change agenda to the highest political level.

4.5 Analysis of local level governance determinants and endowments

At a local level, governance is a major determinant influencing adaptive capacity. Additionally, governance factors, such as, "increased flows of information and knowledge, elements of democratic decentralisation, social capital and networks, interactions and negotiations between institutions and stakeholders at different levels and resource availability and equality" (Engle & Lemos, 2010, p. 6) are critical for adaptive capacity in islands. In this section, I will explore local level governance and the role of social networks and institutions in shaping the adaptive capacity of island communities. In the island communities, formal and informal institutions play a key role in enhancing adaptive capacity. While informal institutions comprise, networks created within the community through social boding and linking, formal institutions represent distinct formal institutional administrative arrangements established in the islands. Examples of formal institutions include the Atoll and Island Councils, government institutions, and NGOs working at the island level. The interactions and negotiations within these formal and informal institutions, through individual and collective actions, are essential to enhance adaptive capacity to address climate change impacts (Engle & Lemos, 2010). The following sections will describe the results of the analysis on local institutions.

4.5.1 Local level governance and institutions shaping adaptive capacity

In coping and responding to climate change stimuli, people living in the islands use various strategies. When people face any climate change related perturbation, reactive and short-term measures are taken to manage and respond to the immediate impacts. Decision making during such climate perturbations is mostly based on local island councillors who assemble and organise collective community action. In islands where the National Defence Force or other formal institutions, such as NGOs are present, initiatives are undertaken by collaborating with them. The informal response mechanisms driven by collective community actions in the past are now more formalised and institutionalised through local island Councils. These institutional arrangements are mainly influenced by the leadership of island councils and social coherence within the communities. Consequently, people often undertake immediate reactive responses through collective community actions but, due to lack of finance, seldom consider undertaking long-term actions pertinent to climate change risks.

Findings from the case study islands indicated the climate change stimuli experienced is similar for most islands. For instance, flooding, due to rain and extreme heat, was experienced by all islands; on the other hand, coastal erosion and storm surges were not experienced on all islands. Additionally, the severity of stimuli differed among islands. For instance, flooding due to rain was a major perturbation experienced in all islands, but the severity and extremity differed among the islands. Now that a broader review of institutional and governance has been outlined, the institutional factors which influence adaptive capacity in each case study island will be explained in the sections that follow.

4.6 Analysis of formal and informal institutions

The following sections will provide the analysis of formal and informal institutions of the five case study islands.

4.6.1 Formal institutions in Ukulhas Island

Ukullhas Island has an elected island Council, a health centre, schools, and the local branch of the State Electric Company. In addition, a women's committee and two NGOs are present on the island. On the island, people have a high awareness of environmental issues and participate effectively in the development of the island. For an example, the island has an effective household waste management program run through the contribution of households. The major climatic perturbations are flooding due to rain, coastal erosion, extreme heat, droughts, and storm surges, respectively. Even though women consider coastal erosion a more severe threat, men consider flooding due to rain as the most critical perturbation faced by the island. The difference in opinion could have arisen since the school was in an area prone to erosion and, as most women take children to school daily, they may have felt that erosion is more critical than flooding due to rain. While storm surges occur annually to varying degrees, extreme heat has been experienced from 2014 onwards. Coastal erosion has exacerbated over the last three years and has severely eroded parts of the island.

To cope with and respond to climate change perturbations, the islanders rely heavily on community cooperation and collective action from the community. Historically, the island chief blows a conch shell to warn people and to assemble them to mobilise the community response to any climate or weather-related perturbations. People then organise and take actions to minimise the immediate impacts. At present, the island council plays a similar role. However, compared to the past, people now rely on technology and machinery, and are generally more aware and financially secure. For instance, when flooding due to rain occurs, the council calls to people on loudspeakers and mobilises the community to drain water from flooded areas.

In Ukulhas, the island council consists of five members belonging to same political party, who demonstrate good leadership. In addition to the island council, the school, utility company, health centre, and NGOs are all considered as critical formal institutions to address climate change perturbations. The Island Council was recognised as the central focal point and the most important institution. In Ukulhas, the council works closely with the community, and organises collective community action to respond to climate change related perturbations. Regarding the role of the council, a key informant mentioned:

> *If you look at the island, the Council is the major centre. It must act as the police, the disaster management centre and MNDF [National Defense Force]. The four to five members of the Council becomes all this. (Uku 02).*

Councils have been given major roles in representing the people of the island at the central level of the government, and in communicating with the public to address various issues faced on the island. The council has been considered efficient in addressing issues faced by people and has been considered very democratic. On praising the council's work, a key informant said:

> *Council works very hard for the improvement of the island. They help the school and helped in building the mosque. They have the know-how and work very efficiently. (Uku 04).*

Regarding the role of other institutions in influencing adaptive capacity, the participants alluded that all formal institutions play some role. For instance, the school creates awareness on climate change and environmental issues through both formal and informal curricula. The health centre also conducts awareness on health issues and provides emergency first aid to people during and after any climate change related perturbations. The utility service provider is also critical in ensuring that much needed services, such as electricity and water, are not disrupted during any such events. Even though two NGOs are present in Ukulhas, they are not institutionalised and, therefore, do not take initiatives, but assist with the community work. On the issue of NGOs, a focus group participant mentioned:

> *NGOs and Clubs work as individuals, like any other citizen. Not as an institutionalised entity. (Uku Men FG).*

Focus group discussions and key informant interviews revealed good networking between council and institutions in the island, as well as good relationships with the central government. However, 70 percent of participants felt that the local level interests are not taken in to consideration by central government. For instance, a key informant mentioned:

> *When island council gives their opinion, government must consider it and must discuss for an amicable solution to issues… But none of this is happening in [central level] government. Consequence of this is different institutions within government doing things differently according to their will. (Uku 02).*

On the challenges faced by the council and formal institutions in the island, lack of financial and human resources was considered as the major impediment. As such, councils are constrained in planning and implementing measures to enhance adaptive capacity of people. Regarding the lack of capacity of council, a focus group participant commented:

> *Council cannot function well due to low financial capacity. (Uku Men FG)*

In addition to lack of resources, the council also lacks knowledge and information on climate change related issues. Even though the council demonstrates awareness on impacts and the effect on people's properties and livelihoods through learning from the past events, they lack adequate knowledge on climate change threats. The councils also lack staff members with technical knowledge on climate change adaptation. Consequently, the capacity to address the impacts related to climate perturbations has not changed with the establishment of the Council. The comment below illustrates availability and use of knowledge by the Council:

> *Well, obviously, now we must be able to cope better than in the past. Now people are more aware. Also, people are financially better off now. In addition, now we have better machinery and equipment. But even now the chain of events [response] goes on as in*

the past. There is nothing much done differently from the past, to address these issues. What I'm trying to say is there is no planned long-term adaptation measures. Plus, there is no specific awareness programs targeted to address such issues. In addition, people living in this impacted area have not taken proactive measures. (Uku 02).

In addition to availability of resources, the council is also faced with challenges in regulating and enforcing measures critical to enhance adaptive capacity. For instance, regulating a building code, such as raising the floors of houses, is not possible as the Council lacks the legal authority to exercise such rules. Even though Council is responding to climate change related perturbations, they have no legal authority or regulatory powers to enforce adaptation measures pertinent to urban planning or designing. Hence, any contingency adaptation measures are at the discretion of the household owners and depend on their financial capacity. While some may build adaptive measures to reduce impacts, others will not take any long-term measures. An interviewee mentioned the importance of regulations and Council's lack of legal authority to exercise such rules:

If we walk around the island we can see a lot of roofs without gutters extended out on to the road. Due to this water drains on the roads causing two to three feet depressions and water logging. This is an issue of regulatory mechanisms. So, to address such issues, council must establish and implement regulations and make people aware of such regulations. … All of this is yet to be done, even after five years since the Councils came (Uku 02).

The focus group discussions and key informant interviews revealed the importance of formal institutions in building adaptive capacity in Ukulhas. The island council was considered the most crucial institution for enhancing adaptive capacity. The participants were unanimous in the view that the council lacks resources and authority to enforce and regulate urban planning measures needed to enhance adaptive capacity.

4.6.2 Informal institutions in Ukulhas

In the island of Ukulhas, people rely on community cooperation to respond and cope with climate change related perturbations. Informal institutions in Ukulhas were based on kinship and ties with neighbours and friends. These institutions are maintained through Islamic values and linking through reciprocity, due to increased awareness and financial capacity. One of the interviewees elaborated on these ties and said:

Well, awareness is more. So, people tend to help each other. We have improved our human resource capacity. People are also more religious now and I think they help more due to being more religious. People are also better off now. (Uku 04).

People maintain the institutional networks and depend on neighbours and relatives for emotional support, as well as for immediate actions to respond to extreme events. This reciprocity enhances their adaptive capacity. One of the interviewees mentioned her experiences in strong networks and helping her neighbours:

My home is very high. We got very little impact. So, I went out with people to help others. ... This [name of a woman] house [referring to her neighbour] was severely damaged and her shop too. Her house was very low and water kept going in. We four started by taking stuff out from shop to a safe place. (Uku 04)

In Ukulhas, such reciprocal relationships were maintained through labour exchange and money was not an influential factor. During flooding events, people were highly dependent on labour exchange. For instance, an interviewee mentioned:

Money is most important. But some people with money also need help if they can't do manual work. In this island people who can do labour are very helpful to poor people too. (Uku 04)

Even though the informal institutions are still strong, people felt that these ties are weakening, mainly due to individualism and political opinions.

Politics is the biggest issue creating rivalry between people. People cooperate but it becomes difficult to work with people having a different mentality. It influences a lot, especially politics. (Uku 01)

The analysis has revealed that in Ukulhas both formal and informal institutional mechanisms are strong and efficient in responding to immediate impacts from climate change related perturbations. Informal social networks are strong, but are slowly eroding due to political differences and individualism resulting from economic opportunities.

4.6.3 Formal institutions in Bodufolhudhoo Island

Bodufolhudhoo Island also belongs to North Ari Atoll, and has an Island Council with members from different parties. The island has a school and health centre, and electricity is provided by State Electric Company, through their branch established on the island. The island has only one registered NGO, but some informal youth clubs are also present. The island does not have any National Defence Force barracks or a Police Station. The island council is considered the most critical institution during the climate change related perturbations faced in the island. The most critical perturbations faced by the islanders are extreme heat, drought, and flooding due to rain, with increases in temperature being most severe. In Bodufolhudhoo, the Island Council works very closely with the island NGO and youth groups. The Island Council also collaborates with the school in providing awareness on environmental issues. One of the interviewee mentioned regarding the role of council:

> *Council plays the most important role to help us. (BF 05).*

Regarding the immediate response during extreme events, participants revealed that the council collaborates with the NGO to organise the relief work. The NGO is also involved in increasing awareness among islanders. On the role of the council, a key informant mentioned:

> *We now have the work force of council. We also have local NGO called AARU and school has a club called SEEP. They all cooperate and help in cleaning and do a lot of work to prevent things like mosquito breeding. (BF 01)*

In addition to the council, the health centre is regarded as the most important formal institution for people when they are affected by various climate change perturbations. The centre provides emergency health care and awareness. Some also mentioned that nearby resorts aid the islanders. On the role of the health centre, a participant mentioned:

> *The Health Centre is very important for us. To respond to heat or water borne disease we need health Centre. I think the Health Centre is the most important institution on this island. (BF 03).*

Even though council is critical and organises immediate action, the lack of capacity in the council, as well as their relationship with central level government. was considered inadequate. Hence, the islanders face challenges in seeking assistance from central government to cope and manage climate change related perturbations. In addition, councils also lack financial resources and equipment to address the impacts. A key informant mentioned:

> *But our community does not have financial capacity to finance a project. So, we need assistance from government. We also have a Health Centre but not enough facilities. So, I would say finance, government assistance and increasing capacity of institutions. (BF 03).*

Almost two thirds of the participants (60%) said that the council is efficient in providing them with assistance and plays a major role in communicating the issues to the central government. For instance, when the island faces shortages in water, due to drought, the council requests that the central government to provide water. The council is also considered efficient in working with other institutions. However, the council has stronger collaboration with the NGO, compared to their institutional cohesion with other public institutions, such as the health centre or utility providers.

4.6.4 Informal Institutions in Bodufolhudhoo

In Bodufolhudhoo, the community is very small and, therefore, close knit kinships were evident. The islanders rely heavily on relatives, friends, and neighbours during any climate related perturbations or events. Their experience in responding to the 2004 Indian Ocean Tsunami revealed the close-knit nature of this island community. One of the key informants reported that:

> *Here we have strong kinship as we have one family in the island and all are related. So, if one is in distress others will help. (BF 02).*

During the tsunami event, all islanders gathered at one home demonstrating their solidarity and social cohesion. This reveals the community cohesion and social bonding are critical for adaptive capacity in Bodufolhudhoo. As one interviewee put it:

> *I can remember during the tsunami one house did not get flooding and so they had electricity while the rest of the houses had no electricity. So, all people every one in the island went to that house for bathing and to use toilet. Also, food was cooked and meals were provided to all of us from one house. So, I can say that during any hardships people are very cooperative and help each other. So, our social bonding and cooperation is the most influential. (BF 04).*

Social bonding is also critical for households where the male household heads are away. For instance, they must rely more on neighbours and friends to respond to any distress they face. Such relationships, based on reciprocity and labour exchange, are critical in an island like Bodufohudhoo, which lacks resources and institutions to respond and cope with extreme events. A key informant described how she depends on neighbours during any climate change related events:

The biggest challenge for me is my husband working outside. But if my neighbours find out I'm having some difficulties they will immediately come and help. (BF 04).

Strong social cohesion and bonding also helps people to rebuild their lives after any perturbations. For instance, in Bodufolhudhoo, community members who are well off provide financial assistance to those in need. Such financial help is critical when there is a lack of insurance or government assistance to rebuild lives and to prepare for future impacts. One interviewee mentioned:

If people had any damage to a home neighbours provide all assistance so if we face any impacts, we can cope. (BF 05)

The narratives from focus groups and key informants reveal that the islanders are confident in continuing the strong kinships. All participants agree the importance of informal institutions built on reciprocal relationships, and alluded that adaptive capacity is enhanced by such informal social networks.

4.6.5 Formal institutions in Hanimaadhoo

Hanimaadhoo is one of the largest industrialised islands in North Thiladhunmathi Atoll of the Maldives. On this island, the major climate change related perturbations experienced were flooding due to rain, coastal erosion, extreme heat, and drought. However, the women's focus group did not consider coastal erosion as a climate change related perturbation, as they believed erosion is caused by coastal modifications. Though not an administrative capital, the island has several formal institutions due to having the only major airport in the upper north of the Maldives, and it is an important economic hub. The island has an Island Council, court, schools, and a health centre. In Hanimaadhoo, regional branches of Maldive's National Defence Force, Maldives Police Service, and Maldives Customs Service are present. In addition, Fenaka Corporation and Airports Company branches are also located on the island, along with a branch of Maldives Meteorology. Hence, the island has several institutions directly and indirectly involved in climate change adaptation. As for other islands, the council is regarded as the most important institution which initiates and collaborates with other institutions. During focus groups a participant mentioned:

Council is most important and must involve with all other institutions. (Han Men FG 01).

Another participant mentioned:

Council can inform government authorities and get assistance. (Han. Men FG 02).

People also discussed the health centre, school, and electricity service provider as playing the most critical roles in coping with climate change perturbations. While the health centre provides emergency first aid and awareness, the school is also involved in raising awareness. The islanders believe electricity is a crucial service for them to cope with the extreme heat, making the Fenaka Cooperation one of the most important institutions in the island. Many also revealed that the MNDF and Police are critical institutions which liaise with the council during climate change related perturbations. Even though the council is considered as the most critical institution that must work with other institutions, some participants expressed that the council lacks the capacity and efficiency to deal with the climate change impacts. A common view amongst the men's focus group participants was the lack of capacity of councils, as one participant expressed with frustration:

Council needs to take initiatives. Council does not function properly; they do not know their roles. (Han. Men FG 02).

The interviews and focus group discussions revealed that the formal institutions established within the island are crucial for enhancing adaptive capacity. However, many participants alluded to the lack of capacity of the council, and the council's lack of knowledge and information in delivering their roles and responsibilities. Nevertheless, they believe the council should be the gateway between the island community and central government, and must address climate change related perturbations through the central government. The institutional cohesion was considered poor while participants agreed the council collaborates with the MNDF, police, and NGOs during any perturbations. One key informant mentioned:

When flooding occurred in the island, youths came out for help and everyone cooperated and worked together. Police station and Defence Force personnel came to help and provided the pumps. (Han 01)

Most participants alluded to lack of resources to respond to and cope with immediate impacts, as well as in adapting for future impacts. Even though several formal institutions are present on the island, the key informants thought the institutions were unable to respond efficiently and, hence, their capacity to cope and adapt is lowered. A key informant expressed her concerns revealing the formal institutions' capacity and said:

Local people have no access to equipment or facilities and rely on government institutions such as National Defence force. Only after severe impacts do people get assistance [from the organisations]. It takes a long time before assistance arrives, [from formal institutions] especially when something happens unexpectedly. (Han 03).

The narratives from people indicated that formal institutions play a key role in responding and coping with climate change related events. However, the institutions lack networking at the island and central levels, and are deficient in resources and knowledge.

4.6.6 Informal Institutions in Hanimaadhoo

Similar to the other case study islands, Hanimaadhoo islanders also rely on strong kinship and reciprocal relationships between relatives, friends and, neighbours. While the island has, different migrant communities settled as part of population consolidation program of the government, the host community comprises the largest group of people. Some believe strong kinship exists within each community, while having weaker inter-community cooperation. For instance, a key informant mentioned that, with regards to the relationships with guest communities and host community in the island:

.... resettlement of people is not good. Recent changes are not good. People now steal our bananas from the farms. In the past, we had no such issues of stealing from our farming areas. Now people steal. Lot of social issues due to increase in number of people. It is not good for us. (Han 04).

Narratives from focus groups and key informants also reveal most people are comfortable financially and can cope and manage impacts. Additionally, compared to the past, social bonding has become weaker due to the influence of money. As such, in Hanimaadhoo, people place more value on monetary gains than other types of informal reciprocal relationships. As mentioned by a key informant:

In the olden days, it was easier to respond to such impacts as people voluntarily help. Nowadays people do not corporate and there is no social coherence. Unless there is a financial gain people will not provide support. People will now provide help only if they get money. (Han 02)

Even though collective community action is weak, strong reciprocal relationships still exist, allowing people to cope and adapt. A key informant revealed how residents help each other and mentioned:

A neighbour had severe flooding and we all came out and helped. We came out and placed sand bags and people helped a lot… People help financially and when our relatives have difficulties we help them. (Han 03).

While kinship and reciprocal relationships, based on labour exchange with neighbours and relatives, is considered critical by some, other people have expressed the weakening of such ties. For instance, a key informant mentioned the weakening of kinship relationships:

People do not corporate and do not have strong kinship. On other islands people do things together. For example, three or four children in a family can get together and build a boat and run a good business. But we don't see such closely-knit relationships. If people live like that we can have more capacity (Han 05)

Overall, these results indicated that social capital and networks are weakened by resettlement of guest communities and influence of money. In addition, reciprocal relationships, based on labour exchange and emotional support, are weakened due to political issues and people becoming wealthier. Hence, the adaptive capacity lowered by the lack of social capital is compensated for by increased financial capacity of households.

4.6.7 Formal institutions in Villufushi

Villufushi has been rebuilt after the 2004 Indian Ocean Tsunami, which devastated the island. The rebuilding of the island took about four years. People returned to the island in 2009 and began living on the island re-built with major infrastructure and facilities. The climate related perturbations experienced in the island, mentioned by male participants, are extreme heat and drought, while in women's focus group, they mentioned short bursts of intense rain as a major perturbation they began experiencing since the resettlement in 2009.

Since 2007, the island's urban planning and management has been administered through the National Disaster Management Centre. Thus, the council must consult with the NDMC regarding any measures they implement or require for adaptation. The island also has a branch of Fenaka Corporation and the Maldives Road Development Corporation. Additionally, the island also has a health centre, a school, and three NGOs. The island council helps people through central government and liaises with the police and school to respond to any climate perturbations. The health centre was also recognised as a critical institution for providing awareness and emergency first aid during extreme events. Regarding the role of the council, a focus group participant informed:

Council is the most important institution. (Vill Men FG 02).

And another interviewee agreed and mentioned:

Council and utility service providers are the most important. (Vill Women FG 01).

While these institutions are critical for coping and managing with the climate change perturbations, lack of capacity and resources were considered the major issue. Seventy percent of participants stated that the health centre is the most deficient, in terms of resources and capacity, and is unable to respond to vector borne diseases and heat related complications. As one interviewee said:

During the dengue outbreak, they could not deal with increased number of patients. (Vill Men FG 06).

Similar views were echoed by other participants regarding the inefficiency of the power station and a participant mentioned:

The power house does not have capacity. (Vill Men FG 01).

In regard to the role of council during perturbations, 70 percent of participants thought that the council communicates with the central government for assistance. In their accounts of the role of the council one participant mentioned:

Mostly we face water shortages and we request council and they help us get government assistance. (Vill Men FG 04).

Another interviewee referred to this and mentioned:

Council communicates with government and provides services. (Vill Men FG 01).

Almost two thirds of participants also expressed the lack of capacity of the council and their inability to make decisions without consultation with the central government. Some participants alluded to the council's lack of cohesion with the central government, and other institutions on the island, was a result of the elected Councillors belonging to the opposition party. On agreeing with others, a participant mentioned:

Council cannot do more due to political divisions and council members political affiliations with the opposition. (Vill Women FG 04).

Like the council, other institutions and NGOs are also considered inactive and inadequate in responding to climate change related perturbations and in enhancing the capacity to cope and adapt. Regarding the Fenaka Corporation, which provides electricity and maintains the sewerage system, a participant commented:

> *Fenaka Cooperation does not do anything during such climatic perturbations. (Vill Women FG 03)*

People resettled on the island in 2009, after the rebuilding of the island. Thus, people have no recollection of any climate change related perturbations which impacted the whole island since then. In addition, the island was reclaimed and raised with coastal defences, making the island safer compared to other islands. As such, people mainly face extreme heat and prolonged dry spells. In the case of extreme heat, people rely on fans and air conditioners, which make their power bills very high. To address shortages in drinking water during droughts, the council provides water to people through the central government. Consequently, people consider that the formal institutions are adequate with the exception of the health centre.

4.6.8 Informal Institutions in Villufushi

Informal institutions, based on social bonding and kinships, have weakened on the island since the resettlement. While some believe such relationships are weakened by political issues, they still think people will continue to help each other if they face any large-scale climate related perturbation. The comment below illustrates the social cohesion and bonding:

> *Our social cohesion is a bit weaker these days. Mainly due to political divisions. But if our social bonding becomes strong and we get funding [financial aid] we can do lot of work to cope and adapt…For instance, if anybody on this island or myself faces any distress or damage to household due to a naturally occurring event, the whole community provides support. (Vill 05).*

However, there were some negative comments and many participants believe that after their resettlement, equity in living standards among them has made them more individualistic. Thus, people do not rely on social bonding. Meanwhile, after the Tsunami, people became heavily dependent on government welfare and support. Consequently, instead of relying on traditional reciprocal relationships, people have become dependent on government welfare. Talking about this issue, a key informant mentioned:

Now we mainly depend on government assistance [welfare]. We have no financial capacity and we must rely on government assistance. ... Finance is the most influential factor. Compared to the past, social coherence is very low now. Now we all are equal in terms of household infrastructure. But not in terms of finance. (Vill 03).

In their accounts of the reason for lower financial capacity, key informants agreed that their traditional livelihood activities have declined after the resettlement, due to the change in the home structures. Their newly built homes lack space for diverse livelihood activities, such as homebased agriculture, fish processing, carpentry, and retail businesses, traditionally conducted within the home premises before the tsunami event. Hence, dependency on government assistance has increased. As one interviewee put it:

Before the Tsunami, most of us women could make dry fish and sell it to earn money. So, in those days we had more diverse financial resources. But now we have no financial resources… Even someone who has skills, such as a carpenter can't do work as they should do it in their home (inside the house). It is the place where people live so it is not possible to do any income generating activity. (Vill 02).

While a few participants mentioned the importance of social bonding and linking to cope with climate related perturbations, most key informants agreed that people have become overly dependent on government aid and are more individualistic. In addition, when they resettled after the tsunami, all families got homes of the same standard and of a higher quality, reducing the gap between rich and poor. Hence, people believe they no longer need to rely on relatives or neighbours, as they have not faced any losses and damages since their resettlement after the tsunami.

4.6.9 Formal institutions of Fuvahmulah

Fuvahmulah is one of the largest and most populous islands of the Maldives, with several formal institutional arrangements. Research participants discussed that they face coastal erosion, flooding due to rain, and extreme heat as major climate change perturbations. Prior to the 2017 local council election, the island had an elected council for each of the eight wards of the island. In addition, the island also had an Atoll Council. At present, the island has one City Council. The island also has other formal institutions, such as a police station and Defence Force barracks, and branches of Fenaka Corporation and Maldives Road Development Corporation. The island also has a hospital, schools and higher education institutions. There are 25 registered NGOs working in the island, for the betterment of social wellbeing and the environment of the island, including the Maldives Red Crescent branch of Fuvahmulah.

Focus group participants were unanimous in the view that the ward council plays the most important role during any climate related perturbations, followed by the Atoll Council. Council takes the initiative and collaborates with other institutions, such as MNDF, the police, and the Fenaka and Road Corporation, to respond during climatic perturbations. Focus group comments below provide an overview of the roles of some of these institutions:

> *Atoll and Ward Council are most critical and play major roles. (Fuv Women FG 01).*

> *MNDF helps with pumps, also Fire and Rescue and Police. (Fuv Women FG 02).*

> *Also, Red Crescent provides lot of assistance. They provide sand bags to homes and help [people]. (Fuv Women FG 04).*

> *Council is the first institution which provides immediate response. (Fuv Women FG 03).*

The role of hospital and health centres includes, creating awareness and providing emergency first aid. In addition, schools and NGOs collaborate with the ward council to provide awareness. As some focus group participants put it:

> *After flooding events the Health Centre initiates [various] programs. (Fuv Women FG 02).*

> *Sometimes we have workshops held by the school and council. (Fuv Women FG 05).*

While several formal institutions are established on the island, the capacity of the institutions is considered inadequate. The financial and human resources are limited and, hence, responding and coping with major events is challenging. The key informants commented, overall, on the lack of resources. As one of the interviewees said:

> *Compared to the past we have more facilities now and we can respond better. But I would not say it is sufficient. We now have MNDF [National Defence Force] support and Councils are very active. But still we do not have [enough] capacity to respond efficiently. (Fuv 03).*

While infrastructure on the island was considered adequate, many key informants believe the capacity to respond and cope is low, due to lack of financial resources and central government assistance. Some also suggested the infrastructure was built with high initial costs, but was not maintained, making it inefficient during climatic perturbations such as flooding. Talking about this issue one interviewee mentioned:

> *Even if we have infrastructure we do not see much benefit. But in case of an emergency we can easily get supply of materials as we have the airport. But often it also does not arrive on time. In addition, the infrastructure we have is not maintained. Even the drainage systems are not maintained and when we get flooding we first need to clean the drains. (Fuv 01).*

While institutional cohesion at a local level is considered adequate, almost two thirds (65%) of interviewees claimed that cohesion between central government and local councils is inadequate. Most of them discussed that the central government have completely neglected them, while others believed the government provides minimal assistance. For example, one interviewee said:

> *[Central] Government support is lacking, making it difficult for us to respond during such events. Councils come and assess damages, but we never get any financial assistance [from central government]. They always promise us but we never get any financial assistance. (Fuv 05).*

Another interviewee echoed similar views and mentioned:

> *Normally people cope on their own. Very rarely government gives any financial assistance. (Fuv 01).*

Another participant agreed to this notion and mentioned that the only tangible assistance is provided by the institutions present on the island and is critical for coping. She mentioned:

> *For us most help is provided by the government institutions, especially MNDF [National Defence Force] and Police. (Fuv 06).*

Interview participants reported that the island has several important institutions leading them to respond and cope during climate change related perturbations more efficiently compared to the past. They also felt that the institutional cohesion within institutions on the island is adequate, even though some felt the Atoll Council does not live up to their expectations. Nevertheless, lack of resources and inefficiency of institutions was considered a major factor limiting their adaptive capacity.

4.6.10 Informal institutions in Fuvahmulah

As the island has a large population, and eight different wards spread over the entire island, community cooperation within each ward was widely regarded as crucial for coping and adapting. Similar to the other case study islands, people in Fuvahmulah are reliant on informal social networks reinforced by reciprocal relationships. Often strong relationships with neighbours, relatives, and friends are considered critical to response during any climate change related events. Commenting on the significance of informal institutions and kinship one key informant said:

> *…sometimes neighbours and relatives provide all assistance. Even if someone's roof is damaged people help in repair work. (Fuv 01).*

Community cooperation and social networks were considered critical when responding to climate change impacts. However, to cope and rebuild lives after any such events, people consider money as more crucial. Hence, even if relationships based on labour exchange during such events are critical, people still find it challenging to cope with impacts. For example, one key informant stated that:

> *Even now social bonding and help from neighbours is the most important thing. Sometimes when we call Police [formal institutions] for help, they take several hours. But our neighbours come and help us immediately. (Fuv 03).*

And another one commented:

> *I think community cooperation and help from neighbours is crucial. For instance, during the last flooding when many trees fell on our house, neighbours came out to help. But due to low financial capacity people have difficulties in coping. (Fuv 02).*

Even though neighbours and relatives help during events such as flooding, people believe that money is becoming more important and influential than reciprocity based on labour exchange. As one interviewee put it:

> *If I'm a poor person, my neighbours will be more hesitant to help me than my rich neighbour. But if a person is rich all people will come to help…. So, money is very influential (Fuv 04).*

People also agreed that their social coherence is weaker now compared to past and even though they have lot of institutions and infrastructure they still depend on help from neighbours and relatives. However, individualism and preferring monetary exchanges over other reciprocal relationships have started becoming more common. Some argued this individualism may be due to economic opportunities, and people becoming more financially independent, compared to the past. Commenting on these aspects one interviewee mentioned:

> *Unlike olden days' people have more job opportunities and the economy is diversified. So, people are more well off…. Due to political differences, people have lost social linkages. But still if we face a major impact people will help. But I think money is more important. (Fuv 01).*

The narratives from interviews and focus groups showed people value informal social networks, and rely heavily on neighbours and relatives to respond to immediate impacts from climate change perturbations. However, financial incentives and monetisation have become more influential over other reciprocal relationships, weakening social bonding, and coherence among community.

4.7 The role of formal institutions in enhancing adaptive capacity.

The list of formal institutions critical for enhancing adaptive capacity mentioned by focus groups includes all government organisations on the islands and non-governmental organisations. While formal institutions on the islands vary due to administrative status and level of development, an island council, a magistrate court, schools, electricity service, and health service are provided on all the islands. Police stations were present on Hanimaadhoo, Fuvahmulah and Villufushi. In Ukulhas and Bodufolhadhoo, there was no police station. Hanimaadhoo and Fuvahmulah had National Defence Force barracks and airport company branches. Additionally, a branch of the Maldives Road Development Corporation was present in the islands of Hanimaadho, Villufushi and Fuvahmulah, as road development projects were ongoing. A hospital was present on Fuvahmulah, while in all the other islands a health centre was present. The only island with piped desalinated water at the time of the field work was Ukulhas, while the only island with a sewerage network was Villufushi. None of the islands had both sewerage and piped water supply at the time of fieldwork.

The types and number of NGOs registered on the islands varied. Most of the island NGOs were established to enhance social wellbeing of the island communities with a broad agenda encompassing various aspects related to socio-economics and environment. Fuvahmulah had the highest number of registered NGOs, at 25, followed by Villufushi with three. Both Hanimaadhoo and Ukulhas had two NGOs, while Bodufolhudhoo had only one. Most NGOs have broad aims and are involved in awareness and in building social cohesion within the island community. While NGOs are directly involved in immediate response during climate change perturbations in Hanimaadhoo and Bodufolhudhoo, they have a more indirect role on other islands. The NGOs in Ukulhas are considered ineffective in responding to climate perturbations. Most participants mentioned that the NGOs on their islands were mostly involved in general environmental awareness including climate change.

Participants, overall, demonstrated that the island councils were the most crucial formal institution at the island level. They also believed the council to be the gate keeper between the island community and central government. In the case of Fuvamulah, the Ward Council functions are similar to Island Councils, while the Atoll Council over-sees and manages their functions. In their accounts of the roles and responsibilities of the councils in responding to climate change perturbations, informants indicated that some councils work more closely with the community and NGOs, while others collaborate with formal institutions, such as MNDF, police, schools and health centres. In all cases, informants reported that strong horizontal integration and cohesion between the councils and other formal institutions in the island are needed. About 70% of participants indicated that centralised policies, plans, strategies, and actions often undermine local views and opinions, making councils ineffective. Most participants believed that the formal institutions need financial support from the central government for their effective functioning.

Findings from focus groups, and key informant interviews on formal institutions, showed that formal institutions have horizontal coordination among each other. However, they lack financial and human resources essential for coping and managing climate change perturbations. Most also noted the lack of coordination with central government and challenges in obtaining financial support from central government. The creation of awareness through mass media and extensive use of social media was considered a major advantage in making people aware. Focus group discussions revealed that, compared to the past, people have become more aware and are doing more to respond to future impacts. Overall, the participants maintained that, to enhance their adaptive capacity, formal institutions and governance mechanisms are crucial.

4.7.1 The role of informal institutions in enhancing adaptive capacity.

Informal institutions based on reciprocal relationships were mentioned by participants from all islands. In all case study islands, strong social bonding and linking between relatives, neighbours, and friends were considered critical for enhancing adaptive capacity. Collective community action during climate change events was considered crucial for enhancing adaptive capacity. Traditionally, people have relied on reciprocity for subsistence, and strong reciprocal relationships reinforced by Islam have become embedded within the societal fabric. As such, reciprocal relationships persist in the island societies. Reciprocal relationships in small, close knit communities were not based on money, even though money influences how people value such relationships in larger islands with more infrastructure. For instance, instead of money, people rely on emotional caring, food sharing, and exchange of labour to enhance the reciprocal relationships in the islands of Ukulhas and Bodufolhudhoo. Households from these islands, where husbands are away, were found to be more dependent on social bonding and reciprocal relationships. However, in Fuvahmulah, Hanimaadhoo, and Villufushi, which have bigger populations and more facilities, people believed reciprocal relationships are based on money exchange and are influenced by wealth.

On all case study islands, people are still willing to maintain the kinship and reciprocal relationships. However, some believe this traditional bonding and linking is becoming weaker. Many people believe community cohesion is weakened by differences in political views and people becoming more individualistic, due to them becoming more comfortable financially. The narratives from interviews showed that adaptive capacity is enhanced by informal institutions and networks existing in the islands. Consequently, people will require other contingencies, such as government aid, to enhance their adaptive capacity, as the reciprocal relationships become weaker.

4.8 Discussion

The findings confirm climate change governance in the Maldives to be authoritarian and centralised. Path dependent, historic institutionalism and the prolonged undemocratic rule have favoured top-down policies on climate change adaptation and mitigation. The major adaptation policy, adopted since 2005 is based on population consolidation, extended with the Safer Island Strategy. This policy neglects the plight of small, marginalised communities in some remote islands. It is evident the policy favours provision of engineered adaptation measures, infrastructure, and other services which enhance resilience and adaptive capacity in larger islands with larger populations. Despite 85 islands having been chosen as priority islands for infrastructure development, the list changes based on the political mindset of the incumbent government. One interesting finding was that population consolidation undermines inter-community cooperation between host and migrant communities, making their traditional community collaborations and other informal institutions addressing climate perturbations less efficient. The findings have important implications on how polices based on AE undermine adaptive capacity of people living on islands.

Even though representative institutions are established to address climate change at a central level, decentralised governance is obscured and deficient due to path dependent historic institutionalism and undemocratic rule in the past. Additionally, lack of capacity at both national and local levels is evident, weakening policy implementation for adaptation. As such, central level AE, based on a technocratic bureaucracy, is imposed on the local level on the behest of the central government. For instance, Safer Island Strategy was not developed through wider consultation with the public, or people living in marginalised communities, and lacks clarity in the implementation. Hence, policy implementation is challenged by path dependent historic institutionalism, lack of democracy, capacity, and democratic decentralisation. These findings may be disagreeable to some, but there are some immediately dependable conclusions regarding how adaptive capacity to climate change is undermined, due to lack of democratic decentralisation and authoritative top down-policies.

A critical policy set forth in the climate change governance regime of the Maldives, was a major mitigation policy, to become carbon neutral by 2020, and was devised by the government elected in 2008. However, this policy has been abandoned by the government elected in 2013. The policy was shifted from a carbon neutral strategy to a low carbon development path, on the premise that becoming carbon neutral may hinder economic development. Even though mainstreaming carbon neutral development is made obsolete, renewable energy projects and emission reduction schemes are prioritised by the government to enhance energy security and to reduce carbon emission. Consequently, there is not much difference in having either a carbon neutral policy or a low carbon development strategy. However, the most contradictory policy in climate change governance, strongly advocated by the current government, is the aspiration for exploration of crude oil within the Exclusive Economic Zone of the Maldives. It can, therefore, be assumed that the current government's policies are more inclined towards AE philosophy. Democratic environmentalism. initiated in 2008, has been reversed with the regime changes from February 2012 onwards, and AE integrated with economic development has become the major policy driver.

These findings show that, in terms of climate change governance, the Maldives have succeeded in international advocacy and in participating in international climate fora over the past 25 years, and continues successfully in this path. However, successes at the local level in addressing climate change adaptation and mitigation are still limited. Policy implementation in governance regime is faced with major challenges, due to a lack of monitoring and evaluation of policy outcomes. In addition, integration of climate change adaptation and resilience in most development projects has been challenged due to lack of environmental planning, mainstreamed to fit adaptation. Mainstreaming adaptation in development is weakened due to lack of knowledge and capacity, as well as the short-sightedness of the governments. One of the issues that emerged from these findings is the adamant mindset in climate change adaptation policies for hard engineering solutions, and population consolidation against the wider scientific views on the complexities and uncertainties of climate change impacts. Hence, mainstreaming adaptation with environmental planning and infrastructure development is crucial.

The in-depth analysis of leadership revealed that political leadership at the highest level is critical for the Maldives to address climate change issues nationally and internationally. The leadership style of the three past governments, before the incumbent government, had stronger commitments and political will to address climate change. According to Steinberg (2012), strong environmental policies are observed under political leaders who have gained environmental awareness through education, media, and civil society engagement. As such, the findings show that leaders of the Maldives who had exposure to environmental issues and international politics were strong climate change advocates, as observed from the government prior to 2008 and the first democratically elected government of 2008. On the other hand, the highest level of the government elected in 2013 has become a laggard in the national and international arena in terms of climate change advocacy.

The findings confirm that the capacity to respond and cope with the immediate impacts resulting from climate perturbations is limited in the case study islands. In most instances, the capacity in terms of resources and man power is limited. However, communities respond through collective community efforts, either through the involvement of civil society and NGOs, or other informal institutions. Even on the islands where the National Defence Force is present, communities cannot rely entirely on government organisations, due to lack of resources and capacity. The analysis indicates that islanders are heavily reliant on assistance from central government for emergency relief and to respond and cope with climate change events. For instance, during severe and prolonged droughts, the council's only choice is to request that the National Disaster Management Centre provide desalinated water. The government also provides disaster relief in the form of money, as well as machinery and equipment, when a sizeable proportion of the island population faces climate perturbations such as flooding due to rain. There are no specific insurance mechanisms or loan schemes to cater for loss of property and damages incurred by people. Hence, people mainly cope and adapt through self-financing, or assistance from neighbours and relatives. Consequently, the island council acts as the gate keeper between people and central government, to mobilise central government action. and is regarded as the most critical formal institution.

At the individual level, people rely on assistance from neighbours and relatives. Informal networks and relationships within the island communities are critical in enhancing adaptive capacity. In the small communities, collective action is more reliable and more valued as a means of enhancing adaptive capacity. However, on the larger islands, the institutional coherence and social bonding essential to organise collective community action are more challenging. Even though neighbours and relatives help each other during climate change events, whole community level action is seldom undertaken on the larger islands, while on the smaller islands, collective response from the community is common. Also, social bonding and linking is limited when different communities exist on the same island. For instance, participants felt that the community spirit on the island is diminishing due to resettlement of other island communities. In addition to inter-community constraints, informal institutions based on reciprocal relationships are weakened by influence of money and politics. Moreover, the formal institutional changes brought in through local governance have resulted in loss of traditional collective community work done by islanders to enhance their wellbeing. For instance, voluntary island cleaning or construction of community buildings are no longer conducted. It can, therefore, be assumed that in larger islands with large communities, informal institutions are weak, while in smaller communities with efficient local governance, adaptive capacity is enhanced, even with minimal infrastructure and resources. On all the islands, reciprocal relationships and strong ties with relatives and neighbours are also maintained as a religious duty. Islamic teaching strongly advocates and inculcates values on treating the fellow community members as brethren. In addition, the homogeneity within island communities reinforces such relationships.

4.9 Conclusion and summary

The present analysis shows that, like in many other SIDS, the Maldives is also in a phase of policy changes and institutional restructuring, while the predicament of international advocacy on climate change is imperative. The findings demonstrate the interdependence of formal and informal institutions on governance, and how central government policies are linked with islanders. Rather than finding major variations among case study islands in terms of institutional cohesion, resource availability, social capital, and effective local governance, I observed that occurrence of lower institutional capacity due to centralised national level policies on adaptation and lack of decentralised democratic governance, is equally impacting all islands. These results are significant in demonstrating the lack of integration of the policies developed, based on AE within local island institutions and challenges in implementation, to enhance adaptive capacity of islanders. In addition, on all case study islands, governance and institutions were considered critical in organising strategies to enhance adaptive capacity; despite this, resources and capacity for collective community actions are deficient. Although, the capacities and numbers of institutions varied among the islands, such limitations are compensated with collective community actions and strong social capital, based on informal institutions.

The conclusion we can draw from the findings is that governance and institutions are critical for adaptive capacity on islands. Nonetheless, there are no major variations among case study islands, in terms of their institutions and governance, which influence their adaptive capacity. The extent to which institutions and governance can influence adaptive capacity is determined by how they interact with each other and the community, and such contingencies are mainly based on delivery of political and economic policies at the national level. While on all islands, the formal and informal institutions interact to deliver short term immediate measures, they lack capacity and resources to enhance future adaptive capacity of communities. As such, long term adaptive measures, taken to enhance adaptive capacity, are currently based on the financial capacity of individual households.

In the next chapter, I will focus explicitly on the social discourse and socio-cognitive aspects of the islanders which influence their adaptive capacity.

CHAPTER: 5 THE ROLE OF SOCIAL DISCOURSE AND SOCIO-COGNITIVE FACTORS IN CLIMATE CHANGE ADAPTIVE CAPACITY OF MALDIVIAN ISLANDS

5.1 Introduction

Having described the influence of institutional and governance characteristics on adaptive capacity in the previous chapter, I will now explore how socio-cultural, socio-cognitive and psychological factors influence the adaptive capacity of island communities of the Maldives. In this chapter, I use a theoretical approach based on resilience and vulnerability, which are critical in shaping the adaptive capacity of islands. I utilised the non-representational dwellings perspective of islandness as the main framing, as described in the methodology chapter (Chapter 3). The analyses provided in this chapter are based on qualitative data gathered from focus group discussions and interviews, as described in Chapter three. The qualitative data analysis involved thematic analysis that explored aspects of climate change driven perturbations experienced over the past ten years, such as perceptions on probability and severity, and coping capacity. A narrative analysis of five to seven interviews with key informants and focus group discussions from each case study island was conducted. Data analysis involved inductive and deductive coding based on the matrix described in detail in Chapter three. One objective of this thesis is to understand how socio-cultural and socio-cognitive aspects are interlinked to climate change adaptation, in influencing adaptive capacity of island communities. The purpose of this chapter is to explore the relationship between adaptive capacity and socio-cultural and socio-cognitive determinants.

5.2 Socio-cultural and socio-cognitive dynamics

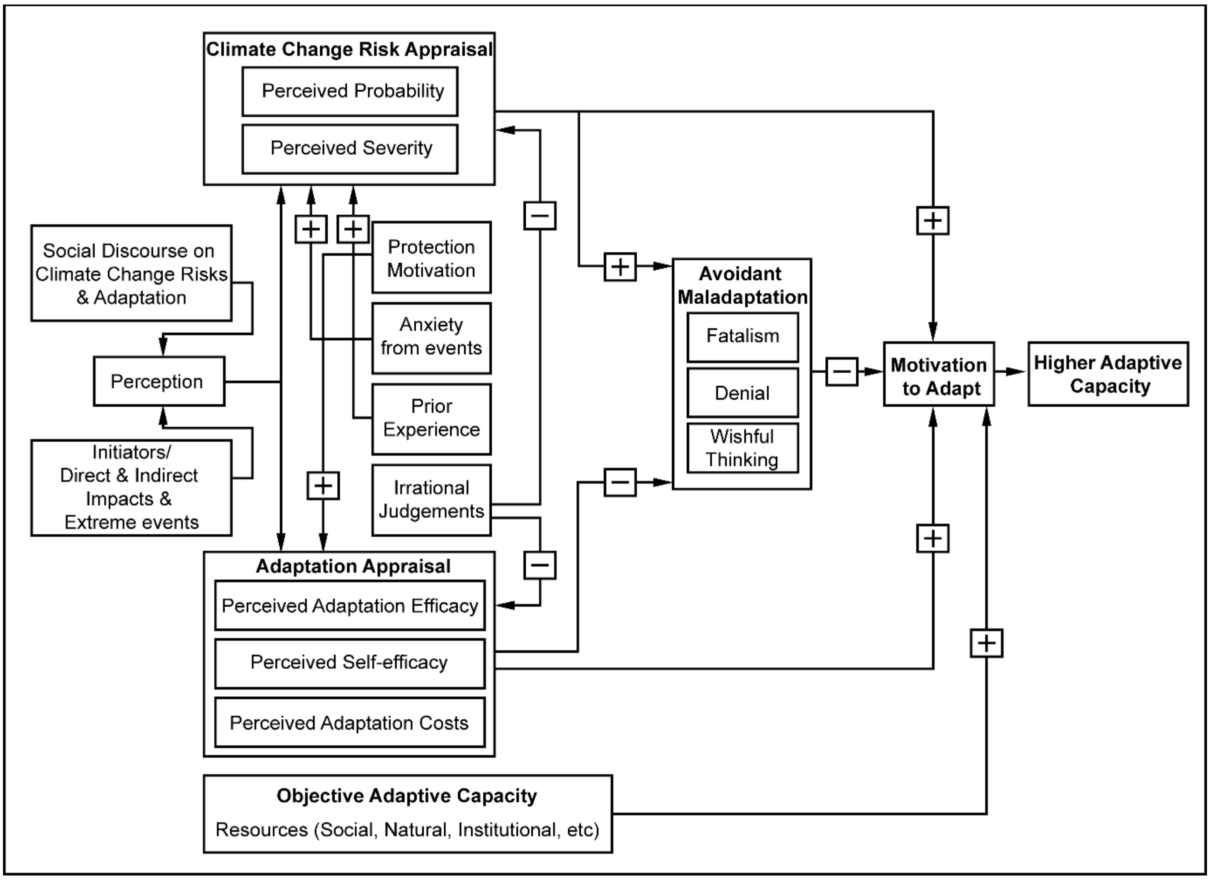
Climate change is a complex phenomenon caused by human actions, triggering an increase in climate extremes impacting both natural and human systems (Intergovernmental Panel on Climate Change, 2014a). However, beliefs, perceptions, and support for mitigation and adaptation to climate change vary among and within nations (Lee, Markowitz, Howe, Ko, & Leiserowitz, 2015). The looming threat of climate change necessitates understanding of the human dimensions of climate change through social and environmental psychological perspectives (Bradley & Reser, 2017). Reser, Bradley, Glendon, Ellul, and Callaghan (2012, p. 58) stated that, community level psychological adaptation involves “behavioural responses and adjustments to the threat and perceived physical environmental impacts of climate change” through individual socio-cognition and adaptive behaviours. Although integration of social and behavioural sciences with natural and physical sciences have gained momentum, psychological perspectives are still poorly addressed (Bradley & Reser, 2017), especially in Small Island Developing States (Thomas & Benjamin, 2017) like the Maldives.

Human dimensions of climate change encompass social and psychological aspects linking "cognitive, affective and motivational processes" that influence how people adapt (Swim et al., 2011, p. 242). In the study of climate change adaptation, social, and psychological facets have become a central issue in understanding community adaptation (Granderson, 2014). Recent evidence suggests that social factors, such as "cultural values, beliefs, worldviews and sense of identity and place", as well as socio-cognitive factors, such as "risk perception, perceived adaptation capacity and motivation for adaptation", are critical determinants of adaptive capacity (Shackleton, Ziervogel, Sallu, Gill, & Tschakert, 2015, p. 331). To understand human dimensions of adaptive capacity in an island context, the framework of this thesis utilised the theory of islandness (Vannini & Taggart, 2013), as an embodiment of relationships underpinned by an array of sensory engagements of islanders with their socio-ecological environment. In view of the theory of islandness, the human dimension of adaptive capacity of island communities can be regarded as a construct of perceived risks and perceived capacity to cope and adapt, through lived experiences of people and their cultural values and beliefs (Granderson, 2014). Furthermore, islandness has inspired people to endure and live with the rhythms of natural events. Islanders have become experts in shifting their ways of life in a dialectical interplay with social and ecological processes by establishing a sense of harmony and balance with their social-ecological environment (Ingold, 2000; Neeraj & Robert, 2001; Vannini et al., 2012; Vedwan, 2006). Consequently, individual and community level perception of risks and experiences are critical for adaptive actions (Adger et al., 2009), and, thus, adaptive capacity of islanders.

Risk appraisal and adaptation appraisal depend on several inter-related factors, such as livelihoods and past experiences, as well as social discourse (Granderson, 2014),physical and psychological factors (Wolf & Moser, 2011). Accordingly, risk perception from a socio-cultural view becomes distinct from the scientific context (Granderson, 2014; Swim et al., 2011). For instance, understanding climate change impacts is often based on the relationship between sense of place and intuitive engagement of people with their physical environment, as well as their experiences of past geophysical events (Reser & Swim, 2011). In most of the studies on climate change perceptions, participants convey their experiences on extreme weather events without explicitly associating them with climate change, while implying such changes in weather as having a direct linkage with climate change impacts (McDonald, Chai, & Newell, 2015). Meanwhile, the scientific projection of the probability and severity of climate change risks are based entirely on long term data and modelling (Granderson, 2014). Consequently, individual and societal understandings of climate change risks are as imperative as the actual scientific projections in determining adaptive capacity (Warrick, Aalbersberg, Dumaru, McNaught, & Teperman, 2017).

Psychological models developed to understand adaptation stipulate that people adapt to climate change related perturbations based on their threat appraisal and coping appraisal (Grothmann & Patt, 2005a, 2005b). For instance, when the perceived severity and probability of risks become greater, affective responses are initiated, leading to higher coping appraisals and enhanced adaptive actions at individual and community levels (Swim et al., 2011). Risk appraisal is also influenced by geographic and cultural factors, such as worldviews, perceptions, and beliefs about climate change (Lee et al., 2015). For instance, sense of climate change threats and coping in a community are influenced by social construction, social representation, and social processes that strengthen or decrease perceptions of risks (Reser & Swim, 2011). Social construction is the process whereby people determine sense of reality of a phenomenon through social discourse, while social representation depicts the paradigm constructed in terms of commonly shared images, views, and findings (Reser & Swim, 2011). Hence, in an island community, social worlds constructed through lived experiences and sensory engagements with the environment, and members within and outside of community, give rise to adaptive practices and competencies that enhance adaptive capacity. Consequently, adaptive capacity of individuals and communities is highly influenced by socio-cultural and socio-cognitive factors.

In the literature review in Chapter two, and the research methodology in Chapter three, the psychological model based on stress and coping frameworks and protection motivation theory, developed by Grothmann and Patt (2005b) (Figure 5.1), was discussed. The model was further elaborated based on information from Reser and Swim (2011). Both these models provided the thematic material for the coding matrix used in the data analysis for this chapter. Reser and Swim (2011) argued that marginalised societies lacking resources and institutional capacity have lower coping appraisals, while Grothmann and Patt (2005b) found that wealth and economic wellbeing do not necessarily amplify coping appraisals. Communities of the Maldives' islands are currently undergoing both direct and indirect socio-ecological environmental impacts due to global climate change, while concurrently being transformed socially, politically, and economically. It has been shown that extreme weather events, such as changes in rainfall patterns and temperature extremes, are becoming more frequent due to global climate change impacts (MEEE, 2017). In the following sections, I will explore findings on perceived threat appraisal and coping appraisal, and the influence of social factors in responding to climate change impacts, on each of the five case study islands.



21. Figure 5.1 Showing the psychological processes involved in climate change adaptation, adapted from (Grothmann & Patt, 2005b)

5.3 The Maldives context

The Maldives is a Muslim island nation in the Indian Ocean, composed of 1,190 islands, with a population of 344,023. The nation has a homogenous population with one culture, ethnicity and language. The population growth rate was estimated to be 1.9 percent per year in 2015 (MFT, 2017). Geographically, the country consists of 26 atolls with 187 inhabited islands (MFT, 2017). About 38 percent of the population resides in the capital Malé. Only three atolls, with an average of 10 inhabited islands, have a population above 15,000. Of the resident population, 44 percent had shifted their residence in the past (May, 2016). A higher internal migration to the capital city is evident, mainly for education and employment. The country has an English education system and a literacy rate above 93 percent. Life expectancy at birth has increased from 48 in 1977 to 76 in 2015 (May, 2016), and is attributed to the improvement of the health sector and the economy. The GDP per capita for 2015 was US$4,466 (MFT, 2017). Tourism is the highest contributor to GDP, with a contribution of over 25 percent (MFT, 2017). At present, two percent of the Maldivian population lives at or below the international poverty line of US$1.90 (UNDP, 2016). Despite this lower poverty level, an additional 8.5 percent are on the verge of the international poverty line (UNDP 2015). The IMF categorisation places the Maldives as an emerging developing economy (May, 2016). The Maldives is a unitary government practising a multi-party presidential system, with a mix of Islamic laws and English common law.

The low lying coral islands have an average elevation of 1.5 metres above mean sea level and the highest point recorded is 2.7 metres (MEE, 2012). In addition, there are no freshwater resources, except a layer of freshwater, formed underneath coral sediments by the percolation of rain water (MEE, 2012). The most critical environmental issues are climate change and the resulting sea level rise, which threatens the existence of the entire nation (MEE, 2016a).

Detailed methodology for this chapter is provided in Chapter three of the thesis. In our interviews and focus group discussions, open ended questions were asked of key informants who were between 25 and 68 years of age. The open-ended questions focused on perceived probability and severity of climate change related perturbations, and impacts on the socio-ecological system of islands. We also used open ended questions to explore how people respond and cope at individual and community level. In addition, barriers to taking adaptive actions were also explored. The following sections of this chapter will provide results from the thematic analysis of interviews, followed by discussion and summary of the results.

5.3.1 Ukulhas Island

5.3.1.1 Climate change risk appraisal

On Ukulhas Island, the majority of respondents assessed flooding due to rain and coastal erosion to be the climate change related perturbations of highest risk faced at the island level, exceeding their ability to cope. Despite this perception of storm surges by participants, the threat of erosion was not clearly distinguished from inundation due to storm tides. While storm tides were considered discrete events, erosion was considered a continuous event influenced by storm tides. Inundation from storm tides was severe and occurred annually on the northern side of the island until 1999. However, with the construction of a harbour in 1999, storm tides in this area have become modest. Focus group discussions also revealed increases in temperature as a major risk, and this was perceived as becoming more intense in recent years, posing major threats, especially in terms of health.

Regarding the risks from climate change perturbations on the island, one interviewee stated:

> *That, I would say is flooding due to rain and coastal erosion (Uku 02).*

And another commented:

> *Flooding due to rain is the most critical extreme event experienced. Next is inundation from storm tides... Yes! Quite severe erosion is also seen near the Thundeekolhu [local reference to eroded area] (Uku 03).*

Extreme heat is also perceived to be another risk of high concern. One key informant reported extreme heat, and said:

> *I haven't experienced any major impacts except the increase in temperature. It is very hot now and it impacts our health. (Uku 06).*

Informants were asked about their perceptions of risks from storm tides and inundation. About half of the key informants mentioned that most people in the community perceive natural seasonal variations in weather patterns, such as waves and currents, have been exacerbated by climate change. For instance, a key informant said:

> *Now there is hardly anyone who refutes climate change. For example, during "adha", [a stormy period marked in the South West Monsoon calendar] the seas get rough [swells]. The place where the petrol shed is built always gets flooded during adha and is known to many people. Consequently, when the construction of a jetty was planned*

for that area for fuel unloading, many people raised concerns on the exacerbation of risks of inundation in this area. (Uku 04).

11. Table 5.1 Perceived severity of risks for the most critical climate perturbations on Ukulhas Island in 2016

Climate perturbations	**Frequency**	**Consequences of perturbations**		
		Economic	**Social**	**Biophysical**
Flooding from rain	2002 and 2007	• Mobility is affected • Damage to infrastructure • Damage to household goods • Major economic activities in islands disrupted • Impacts agriculture	• Mosquitos and other insects increase • Toilet soak pits burst releasing sewage • Spread of diseases • Closure of schools	• Loss of large trees • Roads get puddles and become uneven
Coastal erosion and storm tides	Continuous, since 2007	• Loss of land • Disruption of economic activities • Damage to trees • Damage to critical infrastructure	• Loss of beaches	• Sedimentation of reefs

Regarding perceived severity and nature of perturbations, key informants and focus groups mentioned various consequences from climate related perturbations, including economic, social, and biophysical impacts that could harm their wellbeing and values (Table 5.1). In summary, the informants on Ukulhas believed that the probability and severity of risks are highest for flooding, due to rain and coastal erosion. The perception of the probability of storm inundation was lowest, while extreme heat was considered more probable and frequent. In their accounts of the most critical perturbations, which exceed the resources available, participants mentioned flooding due to rain and coastal erosion as the most probable and severe impacts.

5.3.1.2 Climate change adaptation appraisal and perceived adaptive capacity

People's perceived adaptation efficacy and coping appraisal is demonstrated by anticipated outcomes from adaptive responses, such as raising the floor of houses. Similarly, emphasis on public actions and cost benefits of actions, such as improving drainage in low-lying areas and construction of coastal defences in erosion prone areas, demonstrates the response efficacy of the community. The majority of respondents indicated that the households with the financial capacity to raise homes and newly constructed homes are usually raised well above ground level. However, homes built in the past were at ground level, making them vulnerable to flooding during heavy rainfall, or from inundation during storm surges. More than 80 percent of respondents perceived adaptive actions to be costly but essential and beneficial in enhancing their adaptive capacity.

Key informants indicated that people are now more aware and, therefore, anticipate positive outcomes from the coping strategies for climate related perturbations, making them more cautious. Regarding risk appraisal and response efficacy of people, a key informant said:

> *They [people] do a lot! They lift beds and other things or place bricks underneath furniture such as TV racks and relocate household assets. They try to protect the household assets as much as possible (Ukuk 05).*

Interviewees also inferred that people are more prepared when risk perception becomes higher for a given perturbation becoming more frequent due to climate change impacts. The comment below (Uku 04) illustrates that people are more aware about risks of flooding due to rain and, therefore, take precautions during heavy rainfall.

> *People know what should be done and prepare beforehand during heavy rain. They fill bags with sand and prepare well (Uku 04).*

Respondents also anticipated the outcomes of a household's adaptive responses as positive, demonstrating high levels of response efficacy at household levels. For instance, a key informant mentioned that raising homes is effective in protecting the household during flooding:

> *Nothing happened to my home! My home is very high! We got very little impact... This [mentioned name of another woman] house was severely damaged and their shop too. Her house [floor] was very low and water kept going in (Uku 05).*

Although perceived adaptation efficacy was high, community self-efficacy was low, as the majority perceived they have lower objective capacity at community level. Perception of capacity in terms of finance and human resource was particularly low. Although the community can respond efficiently with immediate response measures through collective community actions, community members still perceive a lack of capacity for long term adaptation. Lack of proactive planning and implementation indicated a low response efficacy at the community level. Similarly, 75 percent of respondents perceived that the costs for coping, such as repairing damage to households and recovering losses, exceed the resources available, making their capacity lower. For example, one interviewee said:

> *Lack of finance and ability to recover from losses is a major issue. Replacing household assets damaged or repairing damages is difficult as we do not have any insurance or other [additional] financial means (Uku 04).*

Regarding the capacity of the community to respond, and perceived community efficacy a participant commented:

> *It is easier to cope now. Now we have mobile phones… Now we do not need to dig channels. We use electric pumps and pipes… Infrastructure is now very much better. People also make very strong homes now (Uku 05).*

Participants' perceptions of the costs of adaptation illustrated that they perceived the costs to be high. The comment below illustrates perceived adaptation costs to respond to extreme heat:

> *We need to spend lot of money to buy air conditioners. It is also costly to use it, as we must pay more for power bills… The main challenge to adapt is lack of finance and money (Uku 06).*

These results show that the community has a higher perceived adaptation efficacy and self-efficacy, but perceived the costs of long-term adaptation measures as generally higher. While higher self-efficacy at individual level leads to raising the homes, community level adaptation measures (e.g., building coastal defences, filling lower areas with sand, or building drainage systems) are considered a constraint for the community, making central government assistance critical. Thus, in the past, some reactive adaptive actions at the community level often became maladaptive, lowering their long-term adaptive capacity. For instance, when channels were dug to drain water into the sea, sediment run off from land occurred, causing damage to the reef. As one interviewee put it:

We responded with reactive adaptation measures. For instance, during heavy rainfall events the community responds by digging channels to drain storm water into the sea, to prevent damage to property. This is not a [permanent] solution for adaptation… For an example, such channels not only discharge water, but lot of mud and sediments are discharged…and the corals in the lagoon of that area is killed or dead. (Uku 05).

Overall, the participants perceived that their adaptation efficacy allows them to anticipate the effects from various climate change related perturbations, prompting them to take adaptive measures, such as raising the floor of homes, and to take collective community actions, such as digging channels to drain water to the sea. Respondents reported that, digging channels is a temporary reactive measure with many disadvantages. Despite this, they indicated that the constraints of resources, and limited capacity to implement transformative adaptive measures, leave them with no other option. As such, most participants demonstrated their adaptation efficacy and perceived self-efficacy as positive.

About 60 percent of interviewees commented that houses built in the past are at risk from flooding, as raising the floor is too costly even though it was regarded as crucial. According to respondents, the key drivers for high adaptation efficacy and self-efficacy were the high awareness and improved financial wellbeing of islanders. Consequently, people use information and knowledge available to take adaptive actions, compared to the past. However, perceptions of the costs of community level adaptations are considered to exceed the resources available on the island. For instance, 80 percent of interviewees mentioned that building engineered coastal protection exceeds the available capacity of the island community and, thus, requires support from the central government. Although people have strong motivation for adaptation, their objective capacity is lowered due to the lack of resources and capacity at the local island level. However, they agree that maintaining coastal vegetation and avoiding sand mining from beaches are effective community level measures, indicating higher response efficacy. In summary, the results showed that subjective adaptive capacity is higher than their objective adaptive capacity.

5.3.2 Bodufolhudhoo

5.3.2.1 Climate change risk appraisal

On the island of Bodufolhudhoo, in all cases, informants perceived the increase in temperature, drought, and flooding due to rain as the most critical climate change perturbations. Perceived severity based on their accounts indicated extreme heat and droughts have the most severe consequences. Participants also spoke about variations in rainfall and increases in temperature becoming more intense, indicating their expectancy of a higher probability of becoming exposed to these impacts. The consequences from major perturbations included economic, biophysical, and social impacts on the community. As one informant said:

> *…we get very hot days and droughts …We now have prolonged drought and have not had any rain even in this year [field work was done in August] … So, I would say within the last 10 years the most notable climate threat for us is intense droughts (Bf 01).*

And another informant mentioned impacts, demonstrating a higher risk perception:

> *In the olden days, we did not experience this kind of heat and had no shortages in drinking water. During those days, our ground water was not bad [not salinized] (Bf 03).*

When discussing changes in rainfall patterns, and perceptions of being exposed to threats from droughts, one interviewee alluded to the notion of the threat:

> *Compared to past we get [sudden] heavy rainfall now. Much heavy rain. During those days, we get more than half a month of continuous heavy rain. But now we have heavy rain just in one day and no rain. Last year also about four months went by, without a single drop of rain (Bf 04).*

The interviewees agreed that the consequences of these irregularities cause shortages in drinking water and salinization of ground water in the island. Most participants agreed that increased temperature and prolonged periods of drought were causing major social and economic impacts (Table 5.2).

12. Table 5.2 Perceived severity of risks for the most critical perturbations by community focus groups on Bodufolhudhoo Island in 2016

Climate perturbations	Occurrence	Consequences of perturbations		
		Economic	**Social**	**Biophysical**
Increased temperature	2014 2015	• Cost of power bill increases • Economic activities disrupted	• Impacts health and wellbeing	• Damage to trees • Roads become dusty • Leads to more extraction of water from ground water lens
Prolonged drought	2014 2015	• Spending on bottled drinking water increases • Household assets damaged due to salinization of water	• Health issues	• Salinization of ground water lens • Damage to large trees

In summary, perceived probability of exposure was highest for increased temperature and prolonged droughts. Participants' perceived severity of consequences of these impacts were also overwhelmingly high compared to resources available, especially droughts. Some of the risks, such as salinization of the freshwater lens, are considered to be major threats. They also consider the risks of droughts and temperature increase will intensify in the future.

5.3.2.2 Climate change adaptation appraisal and perceived adaptive capacity

Adaptation appraisal by the majority of participants indicated anticipation of favourable outcomes from their actions to cope with the climate related perturbations experienced. For instance, planting trees, increasing community awareness, seeking cheaper renewable energy sources, and increasing the capacity of the health centre were considered as possible adaptive actions that could have favourable outcomes to enhance adaptive capacity. Similarly, perceived adaptation efficacy for intense prolonged droughts included adaptation actions, such as increasing rain water storage capacity, installing a desalination plant, and allowing recharging of rain water into the ground. About half the participants emphasised that prayer is particularly important and mentioned that, when droughts become intense, the council organises a congregational prayer. As one participant mentioned:

Council also calls for people to pray [congregational prayer] when droughts prolong and conducts awareness (Bf 01).

Actions taken on the island are essential to enhance adaptive capacity, and one participant commented that capacity to respond to droughts is lacking in the community:

When we get a water shortage, water is supplied by the Disaster Management Centre [Central government organisation in the capital] through the council. (BF 01).

Although people perceived the outcomes of their responses as beneficial for adaptation, most actions were considered reactive immediate measures. Even though a majority of participants perceived these adaptive responses as critical; overall, participants demonstrated lower self-efficacy, as they perceived long term adaptive actions to exceed the resources available in the community, as well as at the household level. Participants agreed that such adaptive actions are too costly to be implemented. As one interviewee put it:

We need a desalination plant as we get shortages in water. But our community does not have the financial capacity to finance a project (BF 03).

About 70 percent of participants also mentioned taking adaptive actions is challenged by the scarcity of land on the island. Hence, housing problems are regarded as a major constraint that lowered perceived self-efficacy. As mentioned by one interviewee:

The island has no capacity as we don't have land. Most homes are too small and congestion is becoming worse. We have a major housing problem (BF 03).

In conclusion, the Bodufolhudhoo case demonstrates perceived adaptive capacity to be higher in terms of perceived adaptation efficacy and perceived self-efficacy. However, their perceived adaptation costs indicated that they lack financial capacity to take both household and community level actions. For instance, building a desalination plant is considered beyond their capacity without central government support, while congestion and housing problems are considered to lower their adaptive capacity. Although some people can take individual level actions, such as raising the floor of homes, the costs of long-term adaptive measures, such as building a water and sewerage system, or rainwater harvesting and storage, are considered beyond the capacity of community. As such, people are unable to take the necessary long-term adaptive measures, even though they have higher self-efficacy and adaptation efficacy. There was no mention of any adaptation actions becoming maladaptive; however, half of the interviewees said that heavy coastal modifications have caused a loss of beach on the island, affecting both visual amenity and local tourism potential of the island. These results indicated a higher subjective adaptive capacity, while objective adaptive capacity was lower.

5.3.3 Hanimaadhoo

5.3.3.1 Climate change risk appraisal

On Hanimaadhoo Island, 80 percent of respondents perceived risks from flooding due to rain, increase in temperature, and intensification of droughts as major perturbations impacting the island. Contrary to the women's views on erosion, men perceived coastal erosion to be a higher risk, while women indicated that erosion is not a major risk and is not related to events exacerbated by climate change. The women's focus group agreed that erosion is caused by coastal destabilisation due to the construction of the harbour. Regarding perceived severity and probability, 90 percent of participants agreed that flooding due to rain and increase in temperature are the most severe and frequently occurring events making them vulnerable. As one interviewee said:

> *We now experience intense rainfall and sometimes we now get three days of continuous rain which we have not experienced in the past. Normally we have very gradual rainfall and rainfall is low compared to south. But now we get a lot of rain. (Han 05).*

Regarding severity and exposure to risks, one participant commented:

> *We get severe flooding in the lower part of the island where Hondaafushi ward is situated. We also feel very hot during the North-East monsoon, especially when there is no rain (Han 05).*

Although droughts were considered a risk, people did not perceive exposure to droughts to be as severe as flooding due to rain or increase in temperature. They agreed that they have the capacity to address water shortages, as the ground water supplies on the island have not become salinized, while all households also have water storage tanks. One informant mentioned that:

> *During droughts and when there is less rain we had to rely on ground water. It happened about five years ago, but now people have water tanks and we have bottled water too. (Han 04).*

A summary of threat appraisal and perceived vulnerability based on focus group discussions is given in (Table 5.3). The risk perception and risk appraisal show the island is most vulnerable to flooding due to rain.

13. Table 5.3 Perceived severity of risks for the most critical perturbations of community focus groups on Hanimaadhoo Island in 2016

Climate perturbations	Occurrence	Consequences of perturbations		
		Economic	**Social**	**Biophysical**
Flooding due to rain	**2013**	• Damage to infrastructure • Economic activities disrupted • Damage to roads • Impacts mobility • Toilet soak pits burst	• Spread of diseases • Social activities disrupted	• Water accumulation in lower areas
Extreme Heat	**Since 2012**	• Disruption of economic activities • Destruction of agricultural crops • Increased dependency on electricity	• Impacts health and wellbeing	• Death of large trees
Coastal Erosion [only Men] FG]	**-**	• Loss of beaches and land	• Affects visual amenities on island	• Loss of trees and damage to coastal vegetation
Prolonged drought	**2010**	• Shortage in drinking water • Lowers agricultural production	• Health issues	• Dirt roads become dusty and pollutes air

5.3.3.2 Climate change adaptation appraisal and perceived adaptive capacity

On Hanimaadhoo, 65 percent of interviewees believed that responses, such as raising homes and digging channels to drain water, are effective coping strategies. As one interviewee said:

> *In those homes, which are at same level as the ground, people place sand bags. Council also responds quickly and using diggers we dig channels in to the beach to drain water in to the sea (Han 05).*

In addition to these adaptive actions, half the interviewees also perceived actions, such as building periphery walls around homes, and filling lower areas on the island with sand, prevent damage from flooding. Similarly, about 60 percent of respondents also believed in protective actions, such as maintaining vegetation to reduce impacts from increasing temperature. In one case, a participant discussed the importance of maintaining vegetation and said:

People destroy large trees and remove vegetation to plant bananas. People have no awareness. I never destroy trees. But most people do such things (Han 04).

Regarding self-efficacy, almost 50 percent of respondents believed that the majority of people raise homes to prevent impacts from flooding. For instance, one interviewee said:

I have noticed that, nowadays people raise their homes to prevent damage due to flooding (Han 02).

On a similar note, another interviewee said:

Most households are aware due to conditions of their homes and they prepare beforehand, especially during rainy season (Han 03).

Approximately 75 percent of participants believe that a majority of people have high perceived adaptation efficacy and perceived self-efficacy. However, costs of adaptation measures are considered high. Talking about costs, an interviewee said:

The biggest challenge is lack of finance as most assets are very expensive. Some very expensive assets like televisions also gets damaged during flooding. (Han 05).

About 75 percent of interviewees believed that, even though adaptation costs are high, most people on the island are financially capable. The comment below illustrates the influence of money on perceived adaptation costs.

I think people are financially more capable now… Money influences more and people with money are more capable than poor people (Han 02).

The results from this analysis indicate that people have higher coping appraisal in terms of their perceived adaptation efficacy and perceived self-efficacy. While half of them believe situation constraints and resource constraints exist at community level, half also think that the council has enough capacity. For instance, one interviewee argued that:

Local people have no access to equipment or facilities and rely on government organisations such as MNDF [Maldives National Defence Force] (Han 03).

Another interviewee had an opposing view, saying:

Council plays a very important role and, we [referring Council] have a digger and other machinery (Han 05).

The results indicate Hanimaadhoo Island has a higher coping appraisal, as the adaptation efficacy and self-efficacy, as well as community resources, are perceived to be sufficient to respond effectively to major threats.

5.3.4 Villufushi

5.3.4.1 Climate change risk appraisal

Risk perception based on perceived probability and perceived severity of climate change perturbations on the island indicated increase in temperature and droughts as most common and severe threats; both men and women agreed on this. However, the women's group believed that short bursts of intense rain were becoming more common and severe compared to the past, and attributed the extremes to climate change impacts. Over 90 percent of respondents agreed that increases in temperature and droughts are the most significant impacts, while half of the respondents reported experiencing short bursts of intense rain. As one interviewee put it:

> *We feel the heat more, and I think it may be due to lack of trees and vegetation. Also, the rainfall pattern has changed. We have less rainfall. Sometimes we get short bursts of rain and no rain for many days (Vill 01).*

Regarding the severity of the threats, approximately 75 percent of respondents believe that droughts and increased temperature are becoming more severe. For instance, one interviewee said:

> *We also face droughts. Water shortages have been faced even this year [referring to 2015] ... It is very, very hot here. I feel it is getting hotter compared to the past. (Vill 02).*

Regarding the probability of events, almost 75 percent of people agreed that rainfall patterns have changed, resulting in droughts. One elderly informant reflected on his past experiences, saying:

> *When we were young, the heavy rain of "Hay Nakaiy" [a period marked in local monsoon calendar] continued for one month and we had nonstop rain for 14 days… During those days, we had accurate and predictable weather patterns… but it is very different now. Everything has changed (Vill 03).*

About 75 percent of people believe these events are becoming more frequent and one participant commented:

> *Now we experience less rainfall and increased temperature. Also, coral in the lagoon is bleaching. We can't bear the heat now…. Now we see more extreme conditions unlike the past (Vill 04).*

A summary of findings regarding the impacts is provided in Table 5.4.

14. Table 5.4 Perceived severity of risks for the most critical perturbations for community groups on Villufushi Island in 2016

Climate perturbations	**Occurrence**	**Consequences of perturbations**		
		Economic	Social	Biophysical
Increase in Temperature	Increasing annually	• Increase in use of electricity • Disruption of economic activities • Fishing becomes poor • Bait fish becomes scarce	• Causes health problems • Day time heat stress • Social activities are disrupted	• Exacerbates droughts causing death of trees and vegetation • Coral bleaching • Dirt roads become dusty and hard
Droughts	Annually, six to nine months of drought experienced	• Agricultural crops die off • Disruption of economic activities • Drinking water shortages causes reliance on bottled water	• Health issues related to respiratory diseases • Drinking water shortages • Homes get dusty	• Ground water becomes turbid and smelly • Trees and vegetation die off • Dirt road surfaces become dusty
Short bursts of intense rain [only mentioned by women's focus group	Annually, during the southwest monsoon	• Damage to household goods • Increased road accidents • Mobility difficulties • Fishermen cannot go fishing • Sea transport is disrupted	• Spread of diseases • Sports activities halted as flood water gets on to sports grounds	• Damage to trees • Flooding in lower parts of islands

5.3.4.2 Climate change adaptation appraisal and perceived adaptive capacity

On Villufushi, perspectives expressed by participants regarding their coping appraisal were similar to other islands. Regarding perceived adaptation efficacy and perceived self-efficacy, people anticipated that their adaptation actions, such as planting trees and increased awareness, would have favourable outcomes in coping with climate change impacts. They also believed that land reclamation to about one and half metres above sea level, revetments, and other infrastructure, built on the island after the tsunami of 2004 were critical in enhancing their adaptive capacity and resilience. Regarding the anticipated outcomes of the adaptive measures and adaptive capacity, one participant commented:

> *We now have good infrastructure such as school and hospital... Now the island is raised, with a revetment covering a large portion [almost entire island] ... So, now we have inbuilt adaptive measures (Vill 02).*

Approximately 80 percent of participants also consider their homes are well built and raised, making the homes more resilient to withstand climate related perturbations such as flooding. Talking about this, an interviewee said:

> *Our homes are beautiful and in good condition. But we don't have any land (Vill 04).*

While the infrastructure allows them to respond efficiently and enhance their capacity to respond to various climate change related impacts, about 65 percent of participants believe that actions, such as planting trees and increasing awareness, is important. As one interviewee put it:

> *For reducing heat, we are now planting more trees and we are creating more awareness (Vill 02).*

About half of the participants also agree that finance is critical and costs of adaptation are high, both in terms of repairing any damage, and using available services like electricity. For example, one interviewee said:

> *We can't even sleep at night due to the heat. Those who can afford air conditioners and can pay electricity uses them (Vill 04).*

Another interviewee commented:

> *Finance is the most important resource. We can't tackle any issues without finance... Not all are capable financially. Before the Tsunami [referring to 2004 Indian Ocean Tsunami] most of us women could make dry fish and sell them to earn money. But now we have no such financial resources (Vill 02).*

The results show that the islanders' coping appraisal is high and both their subjective and objective capacity is high, due to the available infrastructure and adaptive measures built in the redevelopment of the island after the devastation of the 2004 Indian Ocean tsunami. The constraints are mainly related to the lack of finance faced due to challenges in recovering their livelihoods from the impacts of the 2004 tsunami. People's livelihoods are mainly impacted by lack of space in newly built homes to carry out diversified livelihood activities, such as fish processing, carpentry, and home-based agriculture.

5.3.5 Fuvahmulah

5.3.5.1 Climate change risk appraisal

Participants from Fuvahmulah responded and revealed their appraisal of climate change perturbations and the threats they face. About 90 percent of respondents indicated that coastal erosion is the most severe impact faced by the island, followed by flooding due to rain, and the increase in temperature, respectively. In terms of the probability of events, participants were of the view that all these events are worsening, and will become more severe and frequent in future. Commenting on his perception of threat appraisal, one interviewee said:

> *The biggest impact we face is beach erosion. After the harbour construction, erosion has exacerbated. We have also faced flooding due to rain and lot of damage to farms and trees (Fuv 01).*

Regarding increase in temperature and the severity of threats, a participant said:

> *During the past, the temperature was not this high. Now we have above thirty degrees…We never used fans. We used the swing when hot and it was sufficient then (Fuv 03).*

Approximately 70 percent of participants agreed that climate change related events are exacerbating erosion. One participant expressed with despair:

During the past 40 years lot of changes have occurred to the environment of this island. If we cannot respond appropriately to this within a short time, this side [pointing to north-east direction] will erode and homes will be under water (Fuv 04).

The results revealed both perceived probability of risk and perceived severity is highest for coastal erosion and flooding due to rain. Although temperature increase is not considered as severe as these perturbations, 90 percent of participants perceived the increase in temperature is higher compared to the past. Table 5.5 provides a summary of threat appraisal, including the assessment of economic, social, and biophysical consequences of climate perturbations experienced.

15. Table 5.5. Perceived severity of risks for the most critical perturbations by community members on Fuvahmulah Island in 2016

Climate perturbations	**Frequency**	**Consequences of perturbations**		
		Economic	Social	Biophysical
Coastal erosion	Continuing since early 80s	• Damage to some infrastructure such as boat yards • Damage to agricultural crops and homes due to increased sea spray • Loss of land	• Loss of beaches and sand banks impacts recreation	• Damage to trees and coastal vegetation • Loss of land • Loss of beaches and sand banks • Loss of marine life
Flooding due to rain	2012 and 2014 severe cases. Annual/ severe floods once every 10 years	• Disruption of mobility and transport within island • Damage to taro fields • Damage to agricultural crops • Damage to public and household infrastructure • Damage to household assets • Disruption of economic activities	• Spread of diseases • Disruption of social activities	• Damage to trees • Loss of vegetation and trees
Increase in temperature	Since the last 5 to 6 years	• Impacts fisheries • Damage to agricultural crops • Increased use of electricity	• Health problems	• Damage to corals • Damage to vegetation • Dirt roads becomes hardened and dusty

The results indicate that the threats from coastal erosion, flooding due to rain, and temperature increase are major impacts faced by the community.

5.3.5.2 Climate change adaptation appraisal and perceived adaptive capacity

On the evaluation of coping appraisal based on perceived adaptation efficacy and perceived self-efficacy, the results indicated higher levels of coping appraisal. While assessing anticipated outcomes from responses and capacity to adapt, people perceived that the four drains built in 1984 by FAO were useful in the past, but are too small now to drain flood waters, as flooding has become more severe in the recent times. Almost two-thirds of participants (65 percent) said that these drains are important, but not sufficient to respond to severe flooding. As one interviewee put it:

> *We have a drainage system built to drain water in to the sea. But those drains are not efficient… The drains are not even maintained and when we get flooding we first need to clear the drains (Fuv 01).*

Regarding perceived adaptation efficacy, about 80 percent of participants also believed raising homes about three or four feet is important to respond effectively during flooding. The comment below illustrates why people place an emphasis on raising their homes:

> *People now have expensive assets at home and they know that if it gets damaged, there will be no way to recover losses. So, people now raise homes and are more cautious to protect homes (Fuv 04).*

People also believed that technology and availability of information from various sources, such as media, provides awareness to respond effectively. The comment below illustrates how the use of knowledge and information from media is perceived to enhance adaptation efficacy:

> *Awareness is the main reason for people to respond better. Now we can hear weather reports daily on radio and television and we can respond. Few days back, I heard from TV, we may get storm surges. So, I raised all furniture by placing bricks underneath it and placed all food items and appliances on high level. I slept only after doing all this (Fuv 05).*

Regarding perceived self-efficacy, half of participants believed they are able to respond while the other half believed that, without government aid or help from relatives and neighbours, they cannot perform adaptive actions. One participant perceived his self-efficacy as:

> *I don't have any money or ability to respond and cope… During flooding, we had many difficulties (Fuv 06).*

Another interviewee, when asked about his perception on his self-efficacy, said:

> *Government aid is the most important thing for us to cope. But my grown-up children help me, as they earn money (Fuv 05).*

The third aspect of the coping appraisal based on perceived adaptation costs indicated that more than 70 percent of participants believed money is crucial for them to cope and to take adaptive actions. The rest of the participants had similar views but believed money and assistance should come from the government. As one interviewee said:

> *Money is the most important thing for us to cope and respond to these things (Fuv 05).*

Similarly, some believe people are well off, but the frequency of climate change perturbations makes it too costly to adapt and cope. When households are exposed to adverse impacts repeatedly, due to an increase in frequency, adaptive capacity is lowered. As one interviewee put it:

> *I think most people have capacity. Our living standard is becoming higher day by day… What I have noticed is, as these events become more frequent and households face these impacts repeatedly, people do not get time to recover financial losses. For instance, farmers who get impacts from heat may again have to face impacts from heavy rainfall (Fuv 01).*

People also mentioned constraints beyond the capacity of the community to address impacts from coastal erosion. Almost 70 percent of participants agreed that government assistance is critical to respond to erosion. The comment below illustrates constraints in terms of capacity and situation constraints faced by the community.

> *In case of erosion ordinary people can't do anything. It has now increased beyond the level people can respond… Unless government provides aid we can't do much. We can only address small issues we face (Fuv 03).*

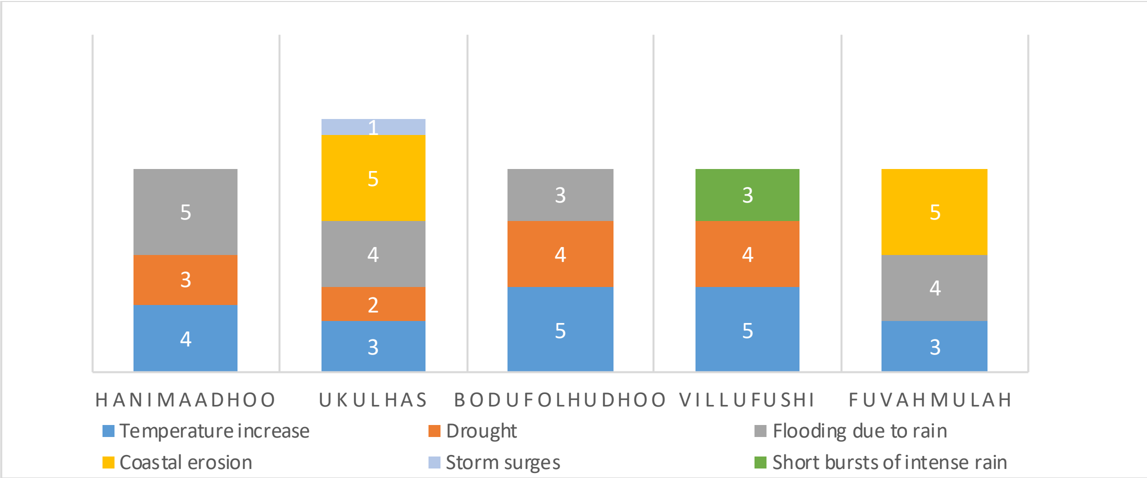
The coping appraisal results reveal people can cope with minor impacts related to loss during moderate events like flooding due to rain. However, for severe impacts, people must rely on neighbours and relatives, and require money and assistance from the government. People anticipated that adaptive actions, such as raising homes, having awareness and financial resources, results in higher objective capacity to respond. Despite this, for most people, money is considered the limiting factor, while half of participants perceived that people are financially capable.

5.4 Discussion

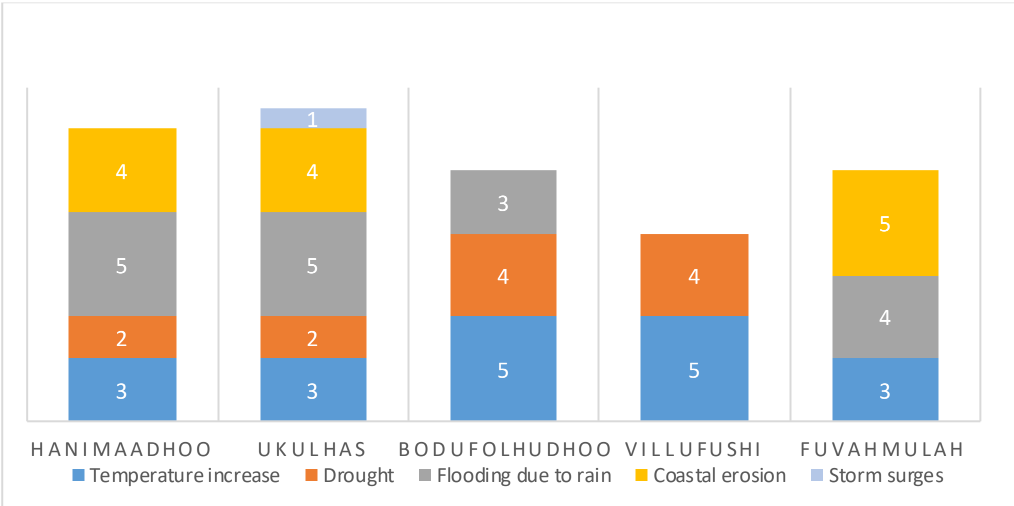
5.4.1 Risk perception

This discussion is based on islanders' perceived adaptation efficacy, perceived self-efficacy, perceived adaptation costs, and their motivation to adapt. Findings from the analysis in this chapter showed that all islanders have experienced discrete extreme events, such as flooding due to rain or storm surges, within the past ten years. Additionally, islanders have been witnessing continuous prolonged perturbations, such as droughts, coastal erosion, and an increase in temperature. The majority of people associated these perturbations with climate change, while some perceive threats, such as extreme heat and coastal erosion, are partly due to human actions, such as removal of vegetation or destabilisation of coastal processes, respectively.

In all the case study islands, increase in temperature was considered the single most intense climate perturbation impacting communities. Regarding severity of increase in temperature, both Bodufolhudhoo and Villufushi participants said that it is the most severe climate change perturbation they experience. The next most critical perturbation according to participants was flooding due to rain. Severity of flooding was highest for Hanimaadhoo Island, followed by Fuvahmulah and Ukulhas, where severity was considered second highest. Coastal erosion was the most severe impact faced by Fuvahmulah, while it was also faced by Ukulhas, to a lesser extent. Erosion was not experienced in Bodufolhudhoo and Villufushi, while the only men's focus group participants on Hanimaadhoo regarded erosion as a perturbation of concern. Storm surges were experienced in Ukulhas only, while only Villufushi female participants perceived short bursts of intense rain as a risk. Both storm surges and short bursts of intense rain were among the least severe impacts according to participants' perceptions (Figure 5.2 & Figure 5.3. The findings also revealed that islands face multiple risks annually, such as flooding due to rain and droughts. Similarly, some threats are continuously experienced, such as coastal erosion and temperature increases. Villufushi experiences the least number of risks and Ukulhas the highest number. The results also showed that, at the household level, the highest consequences are felt from flooding due to rain, causing damage to household assets and properties.



22. Figure 5.2 Perceptions of climate change perturbation experienced on five islands of the Maldives based on female focus groups in 2016; showing the intensity, where 5 represents highest and 1 represents lowest



23. Figure 5.3 Perceptions of climate change perturbation experienced on five islands of the Maldives based on male focus groups in 2016; showing the intensity where 5 represents highest and 1 represents lowest

5.4.2 Perceptions on climate change perturbations

5.4.2.1 Temperature increase

The increase in temperature was widely noted and consistent across all islands. Temperature increase was perceived as having become more intense recently and most people recalled an increase since 2012. Severity of temperature was a major risk for Bodufolhudhoo and Villufushi, while others considered it moderate to high. Most participants believe the increase in temperature is most intense during the NE monsoon from December to February, and during the inter-monsoonal period from March to April. The increase in temperature was also perceived to be associated with low rainfall during this period. In the case of Villufushi, about half of the people also believe that a lack of vegetation on the island is exacerbating temperature increase.

5.4.2.2 Drought

Participants reported that, compared to the past, rainfall during the NE monsoon has dropped, causing prolonged droughts lasting for three to five months. While Fuvahmulah islanders did not perceive drought as a risk, islanders from Bodufolhudhoo and Villufushi considered it a high-risk; for Hanimaadhoo and Ukulhas it was moderate. Participants also experienced shifts in rainfall patterns and mentioned that the intense rainfall predicted during SW monsoon has been more erratic since 2000. For instance, the predicted monsoonal rain in June and July has now shifted to short intense events occurring in August and September. However, on Fuvahmulah, people have not experienced droughts as the southern atolls generally have higher precipitation compared to the northern atolls.

5.4.2.3 Flooding due to rainfall

People perceived that flooding due to rain is becoming more frequent. In all islands except Villufushi, flooding due to rain was considered a high risk. Additionally, severe flooding events, that occur as decadal events have now become more frequent according to participants. For instance, Fuvahmulah usually experienced severe flooding once every ten years in the past, but recently flooding has become a biennial event. Most participants from Fuvahmulah recalled their experiences of flooding from 2012 and 2014. Usually, southern atolls experience more rainfall and, as such, are more prone to flooding due to rain (MEE, 2016a). Participants from Hanimaadhoo believed that rainfall has increased over the years and, therefore, the incidence of flooding is becoming more frequent. Hanimaadhoo people recalled their experiences of flooding in 2007 and 2013. On Ukulhas, severe flooding was experienced in both 2002 and 2007. Bodufolhudhoo has not experienced severe flooding in recent times, but often experiences moderate flooding annually.

5.4.2.4 Coastal erosion

Participants from Fuvahmulah and Ukulhas perceived the highest risks from coastal erosion, while there were no distinct erosion risks pertaining to climate change on other case study islands. Although Hanimaadhoo experiences moderate erosion in a small area near the harbour, a majority of participants suggested that erosion is caused by coastal destabilisation due to the harbour construction. However, the people of Fuvahmulah perceived erosion becoming more intense due to climate change. Participants said that erosion has been ongoing on Fuvahmulah since the 1980s, but became more severe after the construction of the harbour in 2007. Participants from Fuvahmulah perceived both climate change and coastal destabilisation as having a compounding effect on erosion.

5.4.2.3 Storm surges

Storm surges and inundation from storm surges were not perceived as a major risk by participants. Participants from all islands recalled few incidences of storm surges, but have not experienced any severe events in the past ten years, except on Ukulhas. On Ukulhas moderate inundation was experienced on the eastern side in 2011. Participants from Ukulhas believe such inundation is due to stormy weather, and is not directly related to climate change.

5.4.3 Context of imaginaries of risk perception

Islanders who participated in this study used variations in weather, such as temperature increase and rainfall patterns, in their perception of climate change risks. This result may be explained by the fact that, in local language, both weather and climate change are referred with the word "*moosun*". Despite this, participants from our case study islands demonstrated a clear understanding of the variations of weather compared to the past. This perception of risks might be informed by the characteristics of islandness. Although participants had limited scientific understanding of the uncertainties and complexities of climate change impacts, they demonstrated a good understanding of climate related perturbations. Additionally, perceptions of risks were very similar both at intra and inter island scales, maybe due to the homogenous culture, language, and ways of life on Maldivian islands. Despite this, a contradiction was seen between the women and men's focus groups from Hanimaadhoo and Vilufushi. In Hanimaadhoo, women disregarded coastal erosion as a direct impact of climate change. On Villufushi, women perceived short bursts of intense rain as a major risk to them. These contradictions may have arisen because women may have had direct experience of some events. For instance, the islander's everyday life activities and ways of life on the island, and their engagement with their environment, may have influenced their perception of risks and threats (Vannini & Taggart, 2013). Consequently, the perceptions of risks of climate perturbations are understood and structured through personal experiences related to the socio-ecological system of the islands as a "mode of active perceptual engagement" (Ingold, 2000; Vannini & Taggart, 2013).

Risk perception and appraisal may also have been influenced by social factors, as described in the theories of social construction, social representation, and social amplification (Pidgeon, Kasperson, & Slovic, 2003; Reser & Swim, 2011). According to the theory of islandness, islanders share their public realm and social life, and share common values and knowledge (Vannini, 2011). Consequently, islanders' perceptions of climate change risks are socially constructed as a shared ideal with other members of the island community (Reser & Swim, 2011). The theory of islandness further supports similarities of risk perception observed among the majority of islanders in our case studies. Likewise, social representations as consensual understanding of climate change, learned through sources such as media, books, or documentaries as well as public discourse, might also lead to such similarities in risk perceptions (Reser & Swim, 2011). Thus, risks and threats perceived by islanders are not necessarily applicable to scientifically determined risks (Granderson, 2014; Warrick et al., 2017). These results agree with findings by Neeraj and Robert (2001), who suggested that visual salience[1], and impacts on livelihoods and properties, are the major factors influencing risk perception. Hence, intra and inter island risk perceptions in our studies were predominantly similar, as most islanders face similar climate perturbations, in relation to the exposure and vulnerability of biophysical conditions, on their islands as a result of climate change.

Perception of climate change risks and understanding of causality could also be related to an 'imagined' risk perceived through cultural values and worldviews. For instance, participants widely referred to ALLAH, in relation to severity and probability of risks. About 30 percent of respondents identified climate perturbations as an act of God. Participants believed that God's will cannot be stopped, and the extreme events are a divine sign of the end of the world. Although the number of participants with these views is less, this ideology implies how knowledge of risks is reframed in a way to comprehend the complexities and uncertainties and the distant and eventual nature of climate change risks. Maldivian island communities commonly associate God with issues that are difficult to be framed through rational reasoning; this was also found in Tuvalu by Barnett and Campbell (2010), and in Fiji by Lata and Nunn (2012). People who perceive climate perturbations as divine retribution become fatalistic and avoid taking effective coping and adaptive actions (Lata & Nunn, 2012).

Risk perception was also influenced by local knowledge on weather and climate. For instance, the sensory engagement of islanders with their environment may have allowed them to

[1] An intrinsic property of a phenomenon which makes it more observable via psychophysical or physiological processing mechanism (Neeraj & Robert, 2001).

understand and identify various changes in their environment. Hence, many participants perceived that their environment had been undergoing various changes over the past ten years or so. For instance, changes in weather patterns, shifts in seasons, and impacts on coastal marine resources, as well as destabilisation of coasts were identified by participants in association with climate change. However, elderly participants portrayed knowledge of changes by relating the impacts to livelihood activities, such as fishing and farming, pertinent to their observations and the dialectical relationship with their environment. This was similar to what Ingold (2000) described as the dynamic relationship between 'affordances' of the environment and the 'effectivities' of the islanders (Neeraj & Robert, 2001). Interestingly, with the loss of traditional livelihood activities on islands, such knowledge and understandings of climate change risks based on islandness may be lost, making only scientifically framed risk assessments applicable. Thus, these results showed that people can utilise local knowledge to assess severity and probability of risks. The findings demonstrate that personal experience and social construction, based on islandness, play a crucial role in risk perception in island communities.

The findings showed that social representation and social amplification Reser and Swim (2011) processes are less significant in the risk perception of islanders. For instance, participants did not identify sea level rise as a major risk threatening them, as depicted in social representations, or in risk signals portrayed through various media sources. Despite this, some focus groups raised concerns regarding sea level rise. Hence, contrary to the theories of social representation and social amplification, where media and institutionalised authority significantly influence public risk perception Reser and Swim (2011), I found people more dependent on social construction and personal experience in their perception of risks. While both mass media and national institutions emphasise sea level rise as the most daunting threat from climate change to Maldivian islands, participants in this research did not consider sea level rise as a direct threat. This may not necessarily arise because islanders do not consider sea level rise as a major threat, but instead, may be due to the reframing of the scientific understanding of sea level rise from a local perspective (Reser & Swim, 2011). For instance, on islands where people perceived erosion as a major risk, sea level rise was not directly linked to erosion. Hence, the major finding was that local perception of risk is not necessarily based on risks framed externally by institutions outside the islands. Despite this, people's perceived risks fit into scientifically observed changes given by Ministry of Environment and Energy (2015), and are similar to the findings of other studies, such as that by Byg and Salick (2009). Consequently, in communicating climate risks and adaptation measures to island communities, risk perceptions perceived and understood by islanders should be used, instead of referring to externally derived information.

5.4.4 Coping appraisal

Regarding the perceived adaptation efficacy, a common finding from all case islands was that the participants engage in different types of responses both at community and household levels. Participants anticipated their coping strategies and adaptive actions as generally having desired outcomes in coping with perturbations. On all islands, raising of homes was perceived to minimise damage caused to homes and assets, due flooding from rain or storm surges. To adapt to heat, participants mentioned buying fans and air conditioners. At the community level, planting trees was anticipated to be an adaptive strategy to reduce the impact of temperature increase. Furthermore, maintaining coastal vegetation and avoiding coastal destabilisation were regarded as adaptive mechanisms to reduce coastal erosion. Coping responses included both coping strategies and proactive adaptive actions (Table 5.6).

16. Table 5.6 Coping strategies in response to climate perturbations on five islands of the Maldives 2016

Island	Coping appraisal									
Ukulhas	Increasing Community cooperation and collaboration	Raising the level of house	Avoid sand and coral mining from beaches and lagoons	Avoid dumping waste on beaches and lagoons	Placing sand bags on shoreline and near homes during floods	Buying assets like air conditioners and fans	Planting trees	Dredging channels for drainage	Increasing awareness	Conducting special prayers
Bodufolhudhoo	Increasing Community cooperation and collaboration	Buying bottled water	Raising lower areas in island by putting sand	Conserving water	Placing sand bags near homes	Buying assets like air conditioners and fans	Planting trees	Increasing awareness	Conductin g special prayers	Sharing rain water
Hanimaadhoo	Increasing Community cooperation and collaboration	Dredging drainage channels	Draining water using pumps	Raising the floor of house	Placing sand bags near homes	Buying assets like air conditioners and fans	Planting trees	Buying bottled water	Increasing awareness	Sharing rain water
Villufushi	Increasing Community cooperation and collaboration	Ventilating homes	Recharging treated waste water in to ground	Using pumps to drain water	Placing sand bags near homes	Buying assets like air conditioners and fans	Planting trees	Buying bottled water	Increasing awareness	Sharing rain water
Fuvahmulah	Increasing Community cooperation and collaboration	Spraying insecticides	Avoid sand and coral mining from beaches and lagoons	Using pumps to drain water	Placing sand bags near homes	Buying assets like air conditioners and fans	Planting trees	Raising the floor of house	Increasing awareness	cleaning and opening the sluices in drains

Coping strategies   Adaptive strategies (Environmental)   Adaptive strategies (Social)

Participants also perceived that various infrastructure on the islands reduces the risks of flooding or coastal erosion. For instance, on Fuvahmulah, the drainage system and paved roads were considered critical infrastructure to reduce flooding impacts. Similarly, coastal revetment in Villufushi was considered a critical adaptation measure to reduce coastal erosion and storm surges. On Ukulhas, the desalination plant and harbour were regarded as essential. Hanimaadhoo and Fuvahmulah also have an airport, which is regarded as critical for adaptation. Despite this, Bodufolhudhoo only has a harbour, which people perceived as enhancing adaptation. However, the effectiveness of most infrastructure in enhancing adaptation was perceived to be low, due to a lack of coherent adaptation or resilience features in the design of most critical infrastructure. This was also found in the chapter on institutions and governance (Chapter four), which demonstrated a lack of coherent adaptation features in infrastructure constructed by the government. For instance, the majority of participants from Hanimaadhoo and Fuvahmulah believed that harbour construction exacerbated coastal erosion. Similarly, participants from Villufushi focus groups expressed that areas around the harbour wharf are prone to flooding, as it was not raised to the same level as other parts of the island during the reclamation of the island.

Results from the present study also confirmed that both the individual and community level responses to climate change perturbations were predominantly reactive - event-driven strategies to cope during perturbations. While a few of these actions can enhance coping for future events, findings show that such reactive responses often lead to unintended maladaptation (Truelove et al., 2015). Participants also perceived that costs of some event-driven adaptation actions to be high and, therefore, a barrier to coping and enhancing adaptation. For instance, buying assets, such as air conditioners and paying for electricity, was a major concern. However, the majority of participants agreed that social bonding and linking within the community is reliable in organising coping actions, whereas government aid is inconsistent. To respond to immediate threats, people rely heavily on collective community action and help from neighbours and relatives. Most participants anticipated that the government would provide more financial assistance to cope and adapt in the future. Consequently, event-driven responses will eventually become a cost burden in terms of time and social capital, and may lower the future adaptive capacity of communities, if they become maladaptive.

These findings are also in line with those of previous studies, confirming intrinsic motivation as a critical factor for responding to climate change perturbations (Swim et al., 2011). As described in the literature review (Chapter two), the Protection Motivation Theory (PMT) model shows that when people perceive their adaptive responses are effective, high coping appraisal is demonstrated. For instance, as described by Grothmann and Patt (2005a), and Reser and Swim (2011), when perceived severity and probability of risks, perceived adaptation efficacy, perceived self-efficacy, and perceived benefits, compared to the costs of adaptive actions are high, people become motivated to engage in proactive and reactive adaptation strategies. For example, our case studies showed that, due to increased living standards and financial capacity, people tended to invest more on home construction and buying assets. Hence, they anticipated a higher financial loss, making them initiate and engage in adaptive and event-driven responses. However, the majority of participants agreed that lack of financial support mechanisms, such as insurance schemes, credit facilities, and social assistance programs, resulted in barriers to adaptive actions. Consequently, social bonding, linking, and cohesion act as motivating factors. Despite this, social cohesion and bonding have started to weaken due to social, economic, and political transformations. These results corroborate the ideas of Schwarz et al. (2011), who suggested that social bonding and linking and collective community actions can be weakened by monetisation of social interactions among people, and through indirect effects of modernity and democratic politics. The majority of participants in our case study islands reported weakening of their social bonding due to individualism and political divisions, associated with modernity and democratic changes.

Another important finding from the case study islands was that the motivational state of communities is lowered by a high dependency on government aid. For instance, in Villufushi, the tsunami recovery program provided various assistance mechanisms, through financial aid and reconstruction programs from the government and donor agencies. This has led to a perception that the government will, and should, assist the community regarding any climate change perturbations or natural events. Although this victim mentality arises from wishful thinking, people also have a genuine concern regarding the limited livelihood opportunities after resettling on the island. People raised the issue of lack of opportunity to engage in home based economic activities, such as fish processing, carpentry, retail trade, and home-based agriculture, due to the lack of space in the new housing units provided to them. Based on the PMT model it can be concluded that such barriers lower subjective adaptive capacity, as the motivational state of people is lowered. Hence, the present study has shown that even with higher objective adaptive capacity, subjective adaptive capacity or adaptation intention is lowered by wishful thinking regarding eventual government aid. Thus, people rely on event-driven coping strategies, while proactive adaptive actions become deficient. For instance, people on Villufushi considered that they have higher objective capacity, as all homes were of equal standard and the island was being rebuilt as a safer island. Consequently, adaptive capacity is not necessarily influenced by tangible physical capacity, but more by subjective capacity, while adaptation intention is influenced by how motivated the people are.

5.5 Summary and conclusion

The main aim of this chapter was to explore the environmental and psychological factors that impact the adaptive capacity of the island communities of the Maldives. The main objective was to understand how people adapt and cope, based on threat appraisal and coping appraisal. Findings from the five case study islands showed that risk perception is influenced more by direct experience and social construction, while social representations and social processes have less influence. The results have also shown that cognitive biases, such as the association of God with risk perception, and high expectations of government aid, lead to fatalism and wishful thinking, respectively. Taken together, these results suggest that an over estimation of subjective adaptive capacity is present on the case study islands.

Coping appraisals show that people engage in immediate and reactive responses during climate change perturbations and have a high perceived adaptation efficacy. Similarly, the findings confirmed that people have a higher perceived self-efficacy and the perceived costs of adaptation were high. Therefore, the data highlight that people have high intentions for adaptation and engaging in adaptation actions. Despite this, on all islands, most adaptation actions are event-driven coping strategies with low cumulative effects on transforming long term adaptation, while some activities also result in unintended maladaptation. Consequently, without long term adaptations, costs of immediate and reactive responses to events will likely increase in the future, especially when events become frequent and demand strong social bonding. Thus, these reactive measures can lead to a lower adaptive capacity on the islands and will impact their future adaptive capacity. These findings show that response and adaptive actions are mediated by the motivational state of people. Motivational aspects are mainly influenced by the perceived benefits in terms of financial losses that may flow from not engaging in adaptive actions. The findings also confirmed that objective capacity is low in terms of resources, but higher in terms of social support mechanisms on islands, but is becoming weaker.

In conclusion, the results from five case study islands demonstrated that affective and cognitive processes are crucial in risk appraisal and coping appraisal. These results confirmed that social capital is central in enhancing objective capacity, while subjective capacity, based on social construction and social representation, is lowered by high costs, fatalism and wishful thinking. As such, both subjective and objective adaptive capacity are considered to have an equal influence on overall future adaptive capacity. This study has demonstrated that on all case study islands, adaptive capacity is lowered due to lack of resources, fatalism and wishful thinking. Even though people can demonstrate a higher psychological resilience from their cognitive biases, this resilience does not enhance their overall adaptive capacity. The major conclusion from the findings is that, all islands have lower objective adaptive capacity than subjective capacity, with the exception of Villufushi Island. On Villufushi, the people have a higher objective adaptive capacity than subjective capacity. Overall, adaptive capacity in all case study islands was considered low due to the mismatch between subjective and objective capacity.

Having discussed the psychological processes that impact the adaptive capacity of islands of the Maldives, the next chapter will focus on biogeophysical barriers and limits and their influence on adaptive capacity on the case study islands.

CHAPTER 6: SYNERGIES AND TRADE-OFFS AND APPROACHING BARRIERS AND LIMITS ON THE ADAPTIVE CAPACITY MALDIVIAN ISLANDS.

In the previous chapter, I presented the findings on the influence of socio-cognitive factors on adaptive capacity of people living on the islands of the Maldives. Findings from the previous chapter revealed that the case study islands are vulnerable to various climatic stresses. The impacts from these climatic stresses are further exacerbated by biogeophysical barriers and limits of the socio-ecological systems of the islands. Hence, understanding the thresholds associated with biogeophysical aspects, coupled with climate change impacts and anthropogenic factors, on islands are crucial. In this chapter, I will critically examine the influence of biogeophysical barriers and limits on adaptive capacity, caused by climate change dynamics, in synergy with anthropogenic factors.

This chapter aims to answer the research question on, how biogeophysical features result in thresholds on adaptive capacity of islands. The analyses in this chapter are based on changes in the morphology, land use patterns, and environmental degradation of the islands over the course of the last 48 years, from 1969 to 2017. The data were based on satellite imagery and aerial photographs of the case study islands from 1969, 2004 and/or 2005, and 2017. Data were analysed using ArcGIS 10.4.1, to quantify morphological changes including land loss, land gain, and changes in shorelines. In addition, land use patterns including urbanisation, and environmental degradation including coastal destabilisation and vegetation loss, were determined by incorporating focus group mapping exercises with the GIS analysis. This chapter concludes that adaptive capacity in the case study islands is lowered by biogeophysical barriers and limits, and are often exacerbated by synergies and trade-offs between environment and development. For instance, urbanisation and coastal modifications, without coherent integration of transformative adaptation strategies, increase maladaptation and lower the natural stability of islands. The findings from this chapter show that mainstreaming climate change adaptation, with land use and infrastructure development, on islands is critical to enhancing their adaptive capacity. Recommendations based on this chapter would contribute to enhance the Safer Island Strategy and Population Consolidation, currently utilised as major adaptation strategies by the government of the Maldives. Having given an overview of the chapter, I will describe biogeophysical barriers and limits of case study islands based on morphology, land use, and environmental degradation. Subsequently, I will analyse and discuss the results.

6.1 Introduction

SIDS are characterised by small land areas spread over vast spans of oceans, subjecting them to climate change impacts (UN-Habitat, 2015). According to the AR5 of IPCC, an increase in temperature by two degrees Celsius relative to 1850 to 1900, is highly likely by the end of this century. Meanwhile, a rise in sea level by 0.53 to 0.97 meters by 2081-2100 relative to 1985-2005 is predicted under the RCP (8.5) scenario (Nurse et al., 2014). Studies also indicate that sea level rise, temperature extremes, and changes in rainfall patterns are major threats to SIDS, like the Maldives (MEE, 2016b; Sovacool, 2011), which are in imminent danger of losing large proportions of land (Barnett & Adger, 2003). Adaptive capacity of small islands is influenced by economic resources, institutions, governance, technology, infrastructure, and biophysical conditions of their socio-ecological system (Adger & Vincent, 2005). Studies on biogeophysical features of islands indicate high vulnerability to climate change impacts, threatening their adaptive capacity (Elrick-Barr, Glavovic, & Kay, 2015). Consequently, atoll islands, on the frontier of climate change, are faced with critical adaptation barriers and limits, often exacerbated by their vulnerability and exposure (Robinson, 2018). Limits and barriers to adaptation includes biophysical, economic, technological, and social (Adger et al., 2009). Physical barriers encompass biogeophysical aspects which undermine the capacity to cope (Adger et al., 2007). These limits are precariously balanced by biogeophysical thresholds which could be rapidly surpassed, due to climate change impacts. Even though future climate change predictions indicate major threats to SIDS, several studies also show high adaptive capacity of island communities (Hau'ofa, 1993; Schwarz et al., 2011). Consequently, understanding the significance of the biogeophysical limits, barriers and thresholds influencing adaptive capacity of small islands is crucial.

Understanding adaptation limits and barriers has gained interest recently. However, the interchangeable use of terms, such as threshold, limits and barriers, results in ambiguity in applying and understanding adaptation thresholds (Dow et al., 2013). Limits are regarded as formidable thresholds beyond which adaptive strategies cease to reduce vulnerability; while barriers are considered as the obstacles and deficiencies which can be overcome through transformative adaptation (Adger et al., 2007 ; Glavovic, 2015). Despite the vast number of studies on adaptation on islands, there is a dearth of studies focusing on the approaching biogeophysical limits and barriers on their adaptation. However, studies focusing on social and economic barriers and limits have gained interest recently (Lata & Nunn, 2012; McNamara, Smithers, Westoby, & Parnell, 2012; Schwarz et al., 2011).

The biogeophysical barriers and limits on islands have a higher degree of synergy with their vulnerability and exposure, thereby influencing their adaptive capacity (Fernandes & Pinho, 2017). Even though adaptation limits define the absolute thresholds beyond which adaptive capacity ceases, due to intractable irreversible changes, many such thresholds are dynamic (McNamara et al., 2012). This dynamic shift exists due to the interconnectedness of climatic stressors with biogeophysical conditions (Morrison & Pickering, 2013), and the subjective and endogenous nature of these limits (Adger et al., 2009). Nonetheless, critical biogeophysical limits, enhanced by the vulnerability and exposure of small, low lying islands, lowers their resilience (Glavovic, 2015). As a result, the capacity of the socio-ecological system of the islands to adapt and sustain natural stability often becomes constrained (Fernandes & Pinho, 2017). For example, a study on barriers and limits to adaptation in nineteen SIDS revealed that, physical and ecological factors account for 28 percent of the limits and barriers they face (Robinson, 2018). Additionally, the natural thresholds on islands are further stressed by anthropogenic impacts, such as purposeful environmental degradation, unsustainable urbanisation, and coastal destabilisation (Naylor, 2015). Consequently, thresholds on the physical carrying capacity of the islands caused by both natural and anthropogenic factors highly influences their future adaptive capacity (Naylor, 2015).

The natural resilience of small low lying coral islands, such as in the Maldives, is dependent on the natural integrity of their biogeophysical environment (Hopley, 1993). The biogeophysical features which influence resilience on islands include: island size and shape; topography; geographic location within the reef system; size of freshwater lens; coastal and inland vegetation; and health of coastal and marine environments (Hopley, 1993). Despite the importance of natural integrity of biophysical features for resilience, degradation of environmental capital on Maldivian islands has occurred over the last two decades due to population pressures (ADB, 2015), which has increased in built up area and is damaging natural biogeophysical features (Fallati, Savini, Sterlacchini, & Galli, 2017). Anthropogenic impacts, such as urbanisation, coastal modification, and removal of vegetation are causing severe changes in the topography and coastal dynamics on the islands (MFF, 2010), exacerbating their vulnerability to climate change. Similarly, anthropogenic impacts, resulting from previous coral and sand mining, have caused severe effects on the natural geomorphology of the islands

(Naylor, 2015). The small size of islands and their disparity also exacerbates climate change impacts due to the unsustainable expansion of urban style - permanent settlements on the naturally stable centre of the islands (Naylor, 2015). Additionally, with the increase in population and rapid urbanisation, coupled with climate change impacts, critical thresholds of the socio-ecological system of islands are being surpassed. Consequently, the adaptive capacity of islands of the Maldives to future climate change impacts is dependent on synergy and trade-offs between the biogeophysical and anthropogenic factors.

The Maldives relies heavily on large scale coastal marine hard engineering adaptation and reclamation to respond to various climatic stresses. Hard adaptations are regarded as costly structures compromising environmental capital, while lacking the ability to adapt to sudden climactic stressors (Sovacool, 2011). Turton (1999) illustrated how adaptive capacity is linked to limits and barriers in natural environmental capital. Based on his model, the islands from this study can be categorised as adaptive, at socio-ecological thresholds, or as exogenously adapted. Based on this model, inhabited islands modified by anthropogenic interventions can be regarded as having lower natural stability, owing to the destabilisation of the natural dynamics and the integrity of the island systems. Such islands, where coastal destabilisation has occurred due to development of nearshore infrastructure, such as harbours, have lower natural stability and capacity for natural adaptation (UNDP, 2012). Those islands then reach the socio-ecological threshold, owing to pervasive anthropogenic activities surpassing their biogeophysical limits (Sovacool, 2011). On islands, where coastal destabilisation and uncontrolled urban expansion have surpassed the socio-ecological thresholds, complex, costly, exogenous engineered adaptation must be carried out to make human habitations safer.

6.2 Biogeophysical Context of the Maldives

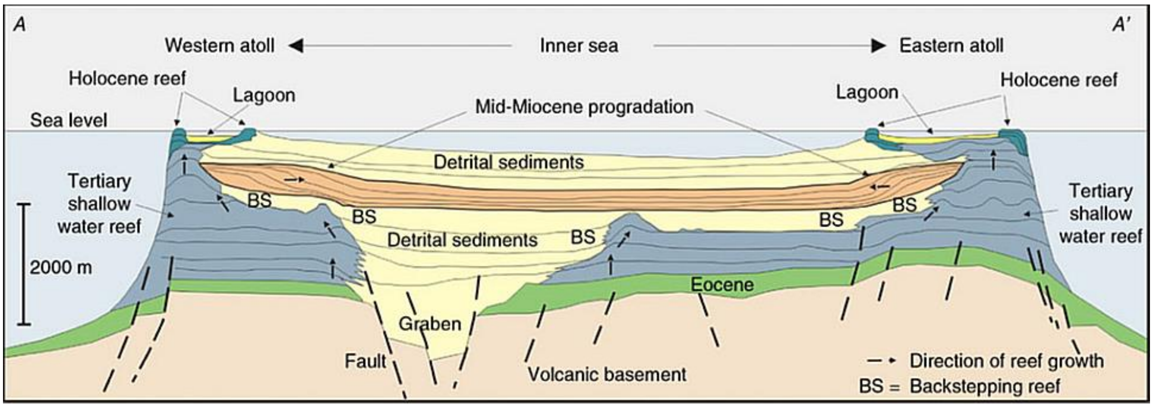
The Maldives consists of 1,192 coral islands spread over an area of 90 thousand square kilometres. The islands of the Maldives are vulnerable, owing to their geomorphology, influenced by both natural processes and anthropogenic factors. For instance, 96 percent of islands of the Maldives are less than a square kilometre, with an average size of 0.7 square kilometres, and an average elevation of 1.5 to 2 meters above mean sea (UNEP, 1986). The majority of the islands are formed on discontinuous atoll rim reef flats, with a complex system of faro reefs and islands, exposing them to various process regimes, such as monsoonal winds and swells (UNEP, 1986). Consequently, adaptation to climate change in the low-lying coralline islands is challenged by physical and anthropogenic barriers and limits.

Despite the critical importance of adaptation to future climate change, the adaptation policies of the Maldives are entirely focused on a hard engineering path (Mohamed & King, 2017). Additionally, major strategies for adaptation lack coherent plans to mainstream adaptation and development (Mohamed & King, 2017). Chapter four of this thesis described governance and policies in detail. Findings from Chapter four indicated that integrating development and climate change adaptation can provide transformative adaptation, which can enhance adaptive capacity of islands. Document analysis of environmental impact assessment reports of major projects on case study islands showed a lack of integration of future climate change predictions, with the design and construction of major infrastructure projects on islands, including coastal modifications and reclamation. Findings also showed a lack of public participation and poor consultation in the planning and implementation of major infrastructure projects on islands. Additionally, resources to enhance transformative adaptation for future sustainability of islands are limited, owing to weaker decentralised governance policies and lack of finance.

6.2.1 Geomorphology of islands

The Maldives is regarded as the seventh largest coral reef system and the largest atoll reef system on Earth. The atoll reef system of the Maldives is formed on a volcanic basement (Figure 6.1), which originated from episodic magmatic eruptions in the Reunion Hot Spot in the Indian Ocean, about sixty-seven million years ago, while the Indian subcontinent was over this hot spot (Bremner, 2016). This volcanic basement was separated from the Indian subcontinent into a mid-oceanic ridge and a carbonate platform edifice was cast upon it (Belopolsky & Droxler, 2003). Calcium rich limestone was deposited on this volcanic basement over millions of years. This limestone partially dissolved during the prehistoric sea level changes, when it was exposed to the atmosphere by a phenomenon called karstification (Woodroffe & Biribo, 2011). These sequential dissolutions of calcium carbonate allowed coral reef growth, by providing a firm substrate for reef growth (Belopolsky & Droxler, 2003). Corals grew and eroded over two million years, with the natural processes coupled with the sea level changes, forming a two kilometre deep carbonate bank on this volcanic basement (Belopolsky & Droxler, 2003). Since about six thousand years ago, the sea level stabilised to the current level and allowed the formation of the modern atoll archipelago of the Maldives on this huge carbonate bank (Perry et al., 2011). This theory of atoll formation is called Karst Control Theory of Atoll Formation and is considered as one of the most modern theories on the formation of the Maldivian reef system (Belopolsky & Droxler, 2003). The Maldives coral reef system consists of 25 atolls, which vary in shape, size, geomorphology, and reef structure

(Naseer & Hatcher, 2004). This includes sixteen complex atoll reef systems, five oceanic faros, and four oceanic platform reefs. The atolls in the north are discontinuous, with numerous patch reefs and faros, while the southern atolls have continuous rims casted up with coral islands (Naseer & Hatcher, 2004).

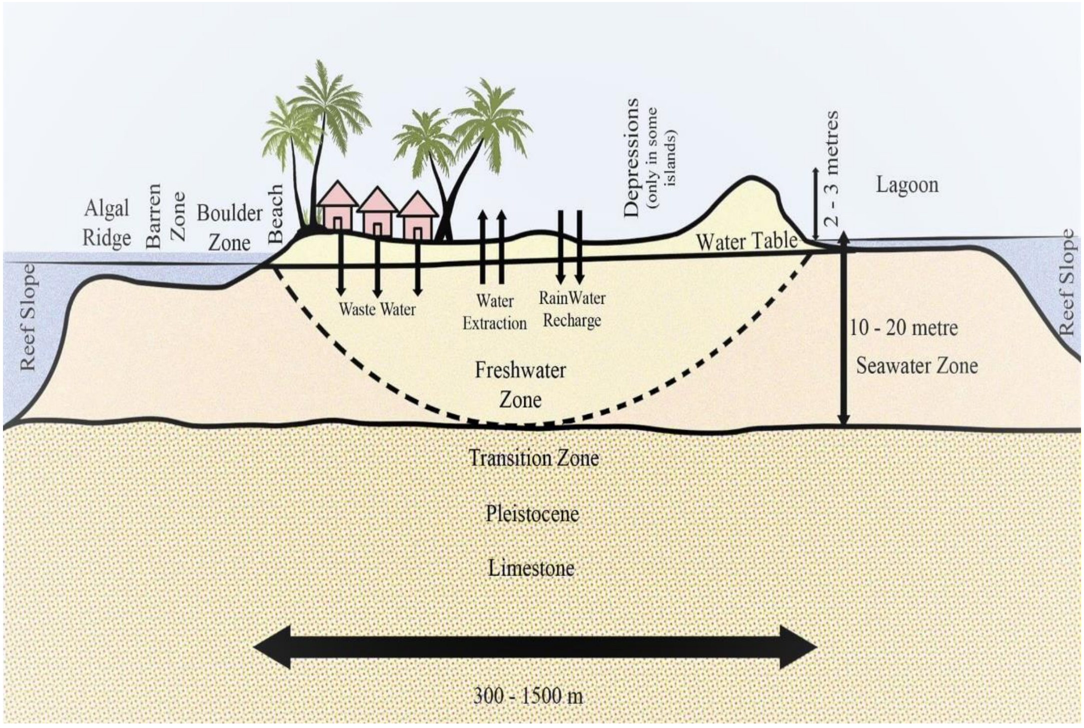


24. Figure 6.1 Geological structure of the Maldives adapted from Belopolsky and Droxler (2003) and Kench (2011).

Atoll islands are formed by accumulation of biogenic calcium rich sediments cast up on atoll rims or shallow patch reefs in atoll lagoons (McLean, 2011). The geomorphological structure of atoll islands of the Maldives constitutes low-lying flat, coralline islands formed on reefs (Woodroffe, 1993). The island reef zonation (Figure 6.2) consists of a reef flat, a reef edge, and a reef slope on the leeward side, while on the open ocean side, the beach and lagoon extend to a coral rubble and corroded boulder zone, followed by an algal ridge, before sloping downwards to open ocean (UNEP, 1986). The vegetation line of the islands is surrounded by the beach berm, which may vary from fine sandy sediments, to coral rubble and coral aggregates (McLean, 2011). A typical beach profile consists of an upper beach of ridges and berms covered by coarse coral sediments and a lower beach of fine sediments (Hopley, 1993). On the outer rim of beach, fine sand particles beneath the unconsolidated coral sediments cemented together to form beach rock and beach conglomerate, stabilising the islands over time (Hopley, 1993; McLean, 2011). However, the unconsolidated sand above the beach rock and beach conglomerate shifts dynamically and are exposed to the influence of tides, waves, and currents, dominated by monsoonal climate and sea level changes (Kench, 2012).

The islands of the Maldives are sedimentary landforms on reef flats, and are not raised up from the seas by volcanic subsidence (Hopley, 1993; Woodroffe, 1993). The reef platform which supports bigger islands are stabilised by conglomerate or cemented beach stone, while younger, smaller islands are reinforced by beach rock (Hopley, 1993; McLean, 2011). On larger islands, the seaward side is mostly covered by deposits of larger sediments, while fine sand is deposited on the leeward side and in areas which curve towards the leeward coast (Ali, 2000). Hence, the seaward sides of larger islands, where wave impacts have the highest influence, are constantly deposited with rocky rubbles and large coral debris (Kench, 2012). The process of sediment deposition, influenced by waves and currents, as well as changes in reef geomorphology and growth, stabilises the sediments resulting in a permanent island. Over time, sand stone or beach stone, and beach conglomerates further stabilise the islands (McLean, 2011). However, stability of reef islands is influenced by geological, biological, and hydrodynamic process regimes (Mann, Bayliss-Smith, & Westphal, 2016).

Islands are in a state of dynamic equilibrium with the climatic regime and oceanographic conditions and, therefore, undergo changes in geomorphology due to sea level changes, wind, and storm regimes (Forbes, James, Sutherland, & Nichols, 2013). Waves and currents act as the major dominating process regimes influencing the island's morphology (McLean, 2011). Consequently, the shoreline dynamics and morphological changes of the Maldivian atoll islands are greatest in areas with highest monsoonal-current variations (Kench 2012). Additionally, factors such as the shape of the island reef platform and location of the island in the atoll also influence shoreline dynamics, resulting in morphological changes in islands (Kench 2012). For instance, circular islands undergo greater morphological changes compared to elongated islands (Kench, 2012). Consequently, a combination of natural processes, such as waves, currents, monsoonal changes, and sea level variations, complemented by biophysical features such as size, shape, and location, determine the geomorphology and stability of islands (Aslam & Kench, 2017).



25. Figure 6.2 Cross section of typical reef islands in Maldives derived from (Church, White, & Hunter, 2006; Woodroffe & Biribo, 2011)

6.2.2 Hydrogeology of islands

Succession of vegetation and accumulation of freshwater from precipitation, during the early stages of island formation, lead to formation of permanent modern coral islands (McLean, 2011). According to Stone (1951) and Cox (1951), over thousands of years, sediments on the top soil layer on islands get compacted by rainfall. Subsequently, the surface of soil gets covered by humus from plant and animal matter, followed by finer sediments, rich in calcium and magnesium (ibid.). Precipitation causes dissolution of calcium carbonate in the coralline sediments and, over thousands of years, a uniform layer of soil without horizontal zonation is formed (ibid.). Permeability of sediments allows percolation of rainwater into the matrix of unconsolidated coral sediments (1-1.5 meters below top soil), forming a fresh water lens, which expands during rainfall (Figure 6.2; ibid.). The size and thickness of this fresh water lens is related to the island size and width, as well as depletion and recharge rate, and sea level changes around the island, as stated by the Ghyben Herzberg theory (ibid.).

In the Maldives, the average, annual rainfall is about 1,750 to 2,300mm (Zahid, 2011), and recharge rate on the islands is estimated to be 40 percent (Ibrahim, Bari, & Miles, 2002). Hence, a typical fresh water lens on an average island has the maximum carrying capacity to support 69 people per hectare, with an average daily usage rate of 95 litres per person (Ibrahim et al., 2002). However, in narrower islands, lacking intact recharge space and higher extraction, the freshwater lens depletes at a higher rate than bigger, wider islands (Bailey, Khalil, & Chatikavanij, 2015). As a result, the ground water becomes too saline for potable purposes in many small, narrow islands. Findings show the thickness of freshwater lens in the majority of inhabited islands in the Maldives is less than 4 meters (Bailey et al., 2015). Additionally, if the sea level rise increases by 6.5mm per year, the tidal dynamics are expected to decrease the thickness of fresh water lens by 11 percent. Similarly, at the current rate of population growth in islands, a 30 percent decrease in the volume of fresh water in the majority of islands is expected by 2030. Furthermore, islands with widths ranging from 300 to 800 meters will become more vulnerable to ground water depletion, due to sea level rise and coastal erosion (Bailey et al., 2015). Consequently, impacts of climate change can surpass thresholds associated with hydrogeology of islands and can potentially lower the adaptive capacity of islands.

6.2.3 Climatology

The climate of the Maldives is driven by the Indian Ocean monsoonal wind patterns and precipitation, involving the winter Northeast (NE) monsoon (January to March) and summer Southwest (SW) monsoon (May to November) (Tomczak & Godfrey, 2003). Slight variations in climate conditions and monsoonal patterns are found in the north and south of the country (Naseer, 2011). The Maldives also experience a transitional monsoonal period from March to April during the SW monsoon, and from November to December in the NE monsoon. During the NE monsoon, the dry winter winds, blown from the Asian subcontinent result in a drier climate, with less rainfall; while in the SW monsoon, wind carried from the east of the African continent blows over the north Indian Ocean, carrying wet wind, causing increased rainfall (Tomczak & Godfrey, 2003). The Maldives never experience full force winds during any monsoons. In the NE monsoon, retention of air pressure by the Tibetan plateau reduces wind force, while 120 degrees reversal of winds, blowing westerly in the SW monsoon, is weakened as they pass over the east of the equator (Tomczak & Godfrey, 2003). Hence, the Maldives only experience steady, moderate winds, which become slightly stronger in central and northern parts. The average maximum wind speed recorded from 1975 to 2001 was 18 ms^{-1} in the central region (Naseer, 2003). However, during SW monsoon, the Tropical Easterly Jet stream over the Indian subcontinent causes cyclonic activities in the Bay of Bengal, resulting in wind gusts of about 110 kilometres per hour, often with increased precipitation and storm surges in the central parts of the Maldives (Tomczak & Godfrey, 2003). For instance, Cyclone Ochki, which developed in the Bay of Bengal in December 2017, caused wind gusts of 60-70 mph with prolonged, intense rainfall. Additionally, in February 2016, Cyclone Roanu developed in the Bay of Bengal, and also resulted in wind gusts of 50-60 mph.

Due to the tropical climate, the Maldives is warm and humid, with a temperature range of 25 to 31 ˚C (MEE, 2016b). The country receives more than 2,700 hours of sunshine per year (MEE, 2016b). In general, the northern parts are warmer than the south, and the warmest weather is experienced from March to May (ibid.). Precipitation is determined by monsoonal reversals and the SW monsoon is marked as the rainy season, with rainfall increasing from the north to south. Based on data from 1992 to 2012, northern parts are found to receive an annual average rainfall of 1,779mm, followed by 1,966mm in central areas and 2,218mm in the south (MEE, 2016). Monsoonal rainfall is influenced by various climate regimes, influenced by global climate change, including snow cover in the northern Himalayas and dynamics in the Indian Ocean Dipole, coupled with El Niño and La Niña events (Baig, 2009). For instance, increasing northern Himalayan winter snow cover decreases monsoonal rainfall (Baig, 2009).

6.2.4 Hydrography

Hydrographic processes, which influence atoll island shores of the Maldives, are dominated by tides, waves, and currents. The Maldives experience mixed diurnal tides, with two high tides and two low tides of varying heights influenced by the Earth's movement (Wadey, Brown, Nicholls, & Haigh, 2017). Spring tides are about 0.1 metre higher than normal, small tides, while neap tides are about 0.25 meters above normal, small tides (Wadey et al., 2017). The predominant wave regime experienced in the Maldives owes to both local and distant process regimes. Local monsoonal winds generate waves, which are strongest from June to August and are lowest from December to January (ibid.). Swells generated from low pressure systems moving between the latitude of 40 degrees south to 50 degrees south predominantly influence the wave regime throughout the year (ibid.). Waves with significantly higher wave heights and longer wave periods are often generated during the SW monsoon, from April to May, due to swell waves generated thousands of kilometres south of the Maldives (ibid.). Such swell waves result in storm surges of 0.5 to 4 metres, mainly during March to November (MEE, 2016).

Surface currents flowing in the Maldives archipelago are also driven by monsoons (Tomczak & Godfrey, 2003). In the NE monsoon, the North Equatorial Currents moving westwards from the Eastern Malacca Straits accelerate to 0.5 to 0.8 ms^{-1} (Tomczak & Godfrey, 2003). From April to June, the Indian Equatorial Jet moves from east to west with speeds of about 0.7 metres per second, which weakens around the equator (ibid.). The South West Monsoon Current begins an eastward reversal flow from July and may accelerate from 0.5 to 1 metres per second in the Northeast of the Maldives (ibid.). In November, the Equatorial Jet resumes with an eastward flow and weakens in January, allowing the cycle of currents to repeat (ibid.). Consequently, hydrography has major impacts on process regimes of islands and their surroundings.

6.2.5 Anthropogenic impacts on islands

Atolls are isolated from continental masses, and atoll islands are spatially bounded, resulting in major limitations in terms of dry land, natural resources, and freshwater (Royle, 2002). Hence, the spatial context and geomorphology of low-lying coral islands also pose critical challenges for human habitation, while exacerbating the potential for climate change impacts. Consequently, people living on islands have formed intuitive interactions with their natural and social environment for sustainable human habitation. However, constraints in land, freshwater and other resources, compound anthropogenic pressures on the island environments (Royle, 2002). In the Maldives and other atoll nations, impacts of climate change on human habitation are a looming threat for the islands, due to a lack of higher ground and fresh water resources (Bridges & McClatchey, 2009). Consequently, anthropogenic factors play a major role in shifting the morphological and environmental dynamics, resulting in barriers and limits to adaptive capacity in the atoll islands of the Maldives (UNEP, 1986).

Anthropogenic impacts, such as improper waste management, unsustainable agricultural practices, uncontrolled urbanisation, and coastal destabilisation exacerbate climate change impacts on islands (Naseer, 2006). As such, adaptation measures to respond to climate change, such as coastal defences and flood mitigation measures, as well as environmental setbacks, have been utilised in several islands of the Maldives (MEE, 2015b). To respond to coastal destabilisation and loss of land, both hard and soft engineering adaptations have been undertaken. According to MEE (2015b), coastal adaptation measures in the most inhabited islands have been undertaken without proper engineering designs. These coastal adaptation measures include foreshore and nearshore break waters, sea walls, and groins adjacent to basin harbours. Land use in the Maldives is also complex due to the state ownership of land and historic institutionalism, which allows a small housing plot for each family for free, based on the availability of land on the island (Naseer, 2006). Land use planning on islands has been centrally controlled with minimal participation of local island communities and is a mere exercise of allocating land for infrastructure development. Currently, the Ministry of Housing and Infrastructure authorises land allocations with minimal role from Island and City Councils.

6.3. Current and future climate projections

Most notable climate change trends in the Maldives from past records show changes in rainfall, temperature, sea level, and sea surface temperature. In addition to annual variations, a decrease in rainfall patterns has been observed over the past four decades, with a decrease of 0.02mm per year for the south, 2.21mm in central parts, and 9.5mm in the north (MEE, 2016b). While the number of rainy days has increased in the northern parts, prolonged drought throughout the country is observed due to the late onset of the SW monsoon (MEE, 2016). Trends in temperature increase show an overall increase in temperature over the decades with an increase in mean average temperature by 0.267˚C per decade in central parts, and by 0.168˚C for the South (ibid.). Decadal records of sea level rise data show an increase of 3.753mm per year for central parts and 2.933mm for the southern regions (ibid.). Northern region records for temperature and sea level have not been assessed due to the lack of long-term data (ibid.). Sea Surface Temperature trends show an increase of 0.11 to 0.15˚C per decade throughout the country (ibid.).

Future projections, based on downscaled Global Climate Models (GCM), showed an overall increase in precipitation over the northern and central parts of the country, with a decrease in the south (MEE, 2016). Projections for temperature increases from the model indicated an increase of 1.8 ˚C for 2021-2050, compared to the increases from 1981-2000 (MEE, 2016). Projections for sea level rise based on GCM indicate sea surface heights to increase by 0.40 to 0.48 metres from 2000-2100 (MEE, 2016). These trends show high vulnerability of the biophysical environment of islands in the Maldives.

The majority of climate change related impacts identified in the Second National Communication of the Maldives (2016) represent biogeophysical impacts and the associated economic impacts. These include extensive erosion, impacts on critical infrastructure, tourism, fisheries, human health, water resources, agriculture, and food security. These impacts are identified in all major government documents, and are associated with natural limits owing to dispersed geography and the low-lying nature of the small coral islands.

6.3.1 Overview of case study islands

6.3.1.1 Bodufolhudhoo

Bodufolhudhoo is located on the north-west inner atoll of North Ari Atoll and is a faro island. The reef platform of the island is oval and is approximately 930 metres long and 720 metres wide. The island is about 11 hectares and is one of the smallest inhabited islands in the Maldives. Due to the oval shape of the island and the reef platform, the island is exposed to monsoonal and swell waves. In the NE monsoon, waves refracted from swells impact the southern side of the island, while in the SW monsoon, the impact is more towards the northern side. The island has undergone severe coastal modifications over the past decade. In 2008, a harbour was built with a major reclamation on the northern side. On the western side of the island, there is some coastal protection in the form of groins and a small revetment, while on the eastern side, a pit enclosed by a sea wall was constructed as a waste dumpsite. The lagoon area around the island has some patchy live corals, dominated by sand and seagrass. Live coral cover is more dominant near the deeper parts, around the harbour entrance channel.

6.3.1.2 Ukulhas

Ukulhas is a small elongated island of about 24 hectares (based on 2016 aerial image analysis), including the beach. The island has a north to south orientation and is located on the eastern periphery of North Ari Atoll and is sheltered by two small, isolated stretches of reef. The island is on an isolated reef flat disconnected from the main atoll, and is a faro island occupying about half of the reef flat. Consequently, the island is exposed to seasonal tropical monsoonal climatic forcing and swell waves, and other oceanographic and climatic factors. The island is flat, with typical coastal vegetation dominated by coconut palms. Due to population growth, rapid urbanisation and coastal modification have occurred on the island.

6.3.1.3 Hanimaadhoo

Hanimaadhoo is located on the eastern rim of the southern part of the Thiladhunmathi Atoll. The island is located on a single, elongated reef platform, approximately 7.5 kilometres long and 2 kilometres wide. The reef and the island are oriented NE to SW. The reef platform is narrower on the north and wider on the south, while the island is broader on the north and narrower towards the south. The NE side, facing the open ocean, does not have a wide reef flat and forms a barren zone with corroded boulders, followed by an algal ridge before sloping towards the ocean. On the western side, a wide reef flat and open lagoon is visible towards the south, and patchy live corals are found beyond the sandy lagoon. The island is about 300 hectares in size and is among the largest inhabited islands in the Maldives. The island has some depressions and has an intact coastal vegetation belt. Coastal destabilisation on the western side is evident due to the harbor and jetty built on this side. The island has a beach of fine sediments on the western side, and coarser coral debris and sand are found on the eastern side.

6.3.1.4 Vilufushi

Vilufushi is in the north-eastern corner of the Thaa Atoll, set upon the long stretch of outer rim reef, consisting of eight other islands. Vilufushi was located about 800 metres away from the oceanward reef edge but close to the lagoon ward reef edge (300m). The depth of the reef flat around the island is shallow, averaging less than -1 metre above mean sea level. The original island had an elevation ranging from +0.8 to +1.5 metres above MSL (EDC, 2006). The island is located on an east west orientation. The original island was about 21 hectares and was heavily urbanised with a population density of 70 persons per hectare. The island is sheltered from process regimes involving swell waves, but is prone to strong monsoonal wind driven waves. Since reclamation in 2005, the island size has increased to 63 hectares and has been raised by an average of 1.4 metres above mean sea level. The island is protected by an artificial ridge and a revetment elevated to 2.4 metres above mean sea level.

6.3.1.5 Fuvahmulah

Fuvahmulah is formed on a reef platform as a single reef-top island and is the third largest island in the Maldives. The coastal belt of the island spans over 15.3 kilometres. The reef edge and reef flat of the island are prominent from the southern side of the island. The maximum distance between coastline and the edge of reef flat is about 200 metres. A steep drop from about 1,000m occurs approximately 2.5-3 kilometres off the eastern side of the reef, and a gradual sloping reef extends to about 2km on the south-eastern side at a depth of approximately 5-10m. Fuvahmulah is approximately 4.42 kilometres long and 1-1.4 kilometres wide with an area of 470 hectares. The coral island has hard beach rock exposed on the outer rim of the island. As with most inhabited islands, the biophysical and anthropogenic environment of the island had been impacted by both natural and anthropogenic factors. Fuvahmulah experiences a process regime of strong wave energy influenced by southwest monsoon winds. The island has also undergone vegetation clearance, coastal modifications, and land loss due to removal of sand from the beaches around the island.

6.4. Data and Methods

Aerial photographs were obtained from the Land and Survey Authority of the Maldives (MLSA) for the five case study islands, from 1969, 2004 and 2005, and Google Earth images of 2016 and 2017 were captured from Google Earth Pro. The aerial photos obtained from MLSA were scanned copies from original negatives and, due to repeated copying and scanning for duplication, the resolution of the pictures was very low (less than 100 dpi). The scale and resolution, as well as exact time of the image capture, were not available due to poor records. The photographs were georeferenced using the ArcGIS base map, to the WGS 1984 UTM zone 43N projected coordinate system, using 5-10 reference points for each photograph. The reference points used included permanent features, such as buildings, road intersections, coastal structures, and permanent reef patches observed in both the images and the base map. Images were transformed in ARCMAP, ensuring an RMSE error lower than 10m for all photographs. The only exception was the 1969 aerial picture of Hanimaadhoo, where one single picture of the whole island was not available, leading to the merging of two aerial pictures taken in the same year.

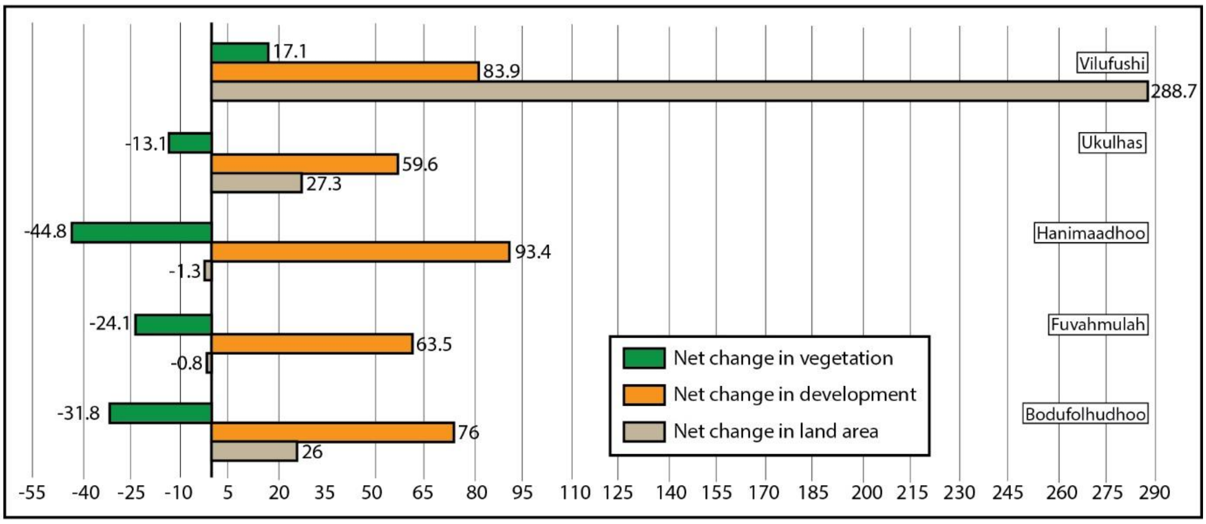
The Edge of Vegetation Line (EVL) was used, instead of the base of beach, as the outer boundary of each island to determine changes in geomorphology of island. However, this does not ensure the net land loss due to coastal change alone. Digitisation of georeferenced images was manually conducted and interpreted by the primary researcher for consistency. Digitisation was done for the EVL, land cover, and land use in the islands for each photograph of each island. The features classified were the shoreline (based on EVL), vegetation cover, and development footprint (built up and cleared areas for residential and commercial purposes including agriculture). During this process, knowledge gained from filed observations and PCCAA mapping exercise were integrated with GIS data to explore the changes in the biogeophysical environment. The mapping exercise involved identifying areas of the island prone to different climate stresses, and natural and engineered adaptation in the islands.

6.4.1 Uncertainties and errors

Due to the low resolution of photographs, and digitisation of shoreline based on EVL, fuzziness in data was high. For instance, due to the dynamic nature of the shorelines through exposure to both continuous and episodic natural events, shifts in the beach sediments are common, increasing fuzziness in analysis (Adnan, Hamylton, & Woodroffe, 2016). In addition, geo-referencing errors are also expected to arise due to lack of identifiable permanent structures from older photos. Hence, permanent coral patches and beach conglomerate were used as reference points for some islands, leading to large RMS errors. Maximum displacement error for well-defined points is expected to be within a range of ± 2 meters. Even though most studies on atoll islands use edge of vegetation for digitisation (Ford, 2012, 2013), the dynamic nature of shorelines and possibilities of vegetation loss over the 47-year period, could lead to errors and fuzziness in analysis. To minimize the errors, digitisation and geo-referencing were repeated, ensuring the pictures were superimposed to best fit to the base map. Additionally, results were compared with data from the latest publications on the same islands and were found to have discrepancies of ±500 meters. The low resolution of 1,969 aerial pictures also led to high distortion errors and is expected to be of a range of ±2 metres. Hence, these inevitable errors are expected to increase fuzziness within a range of ±10 meters in comparison to the actual scale.

6.5. Results

In all case study islands, major changes in land use, land cover, and coastal modification have occurred over the past 47 years. Urbanisation, environmental degradation, and coastal destabilisation was evident in all case study islands.



26. Figure 6.3: Biogeophysical changes in islands over the past 47 years as a percentage compared to 1969

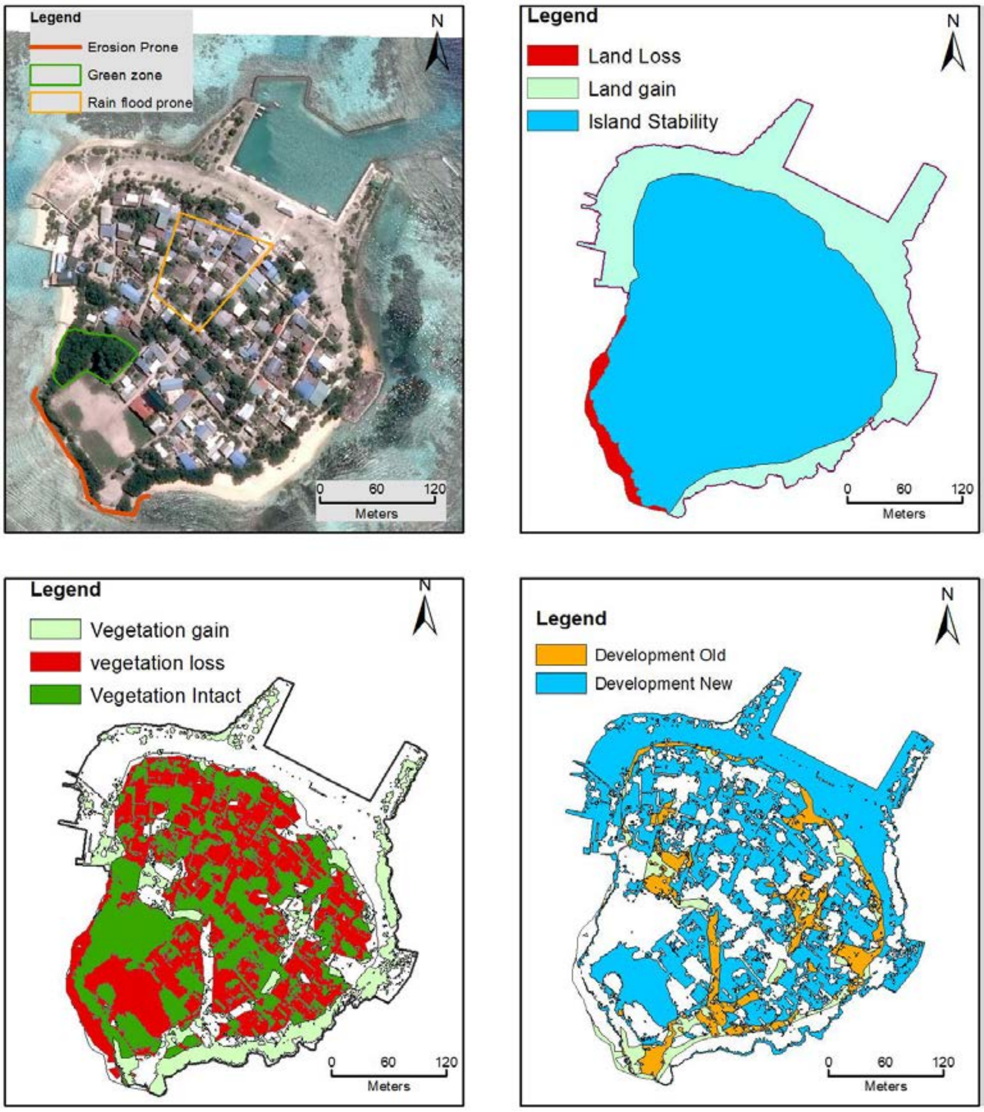
17. Table 6.1: Demographic and biogeophysical features of islands (data based on analysis of 2017 Google Earth imagery)

Island	Area (hectares)	Population excluding foreigners	Annual population growth rate	Population density per hectare	Urban and built up area (hectares)	Vegetated area (hectares)	Coral reef area (hectares)
Bodufolhudhoo	10.5	584	2.95	55	6.3	4.3	37
Ukulhas	21	921	4.75	44	10.4	10.6	58
Hanimaadhoo	292	1616	3.67	6	133.6	158.4	779
Vilufushi	58.5	976	*48.36	16	50.2	8.2	105
Fuvahmulah	484	7984	0.68	16	158.3	325.3	472

* Vilufushi has higher population growth rate as the population was temporarily evacuated in 2004 and moved back by 2014

6.5.1 Bodufolhudhoo

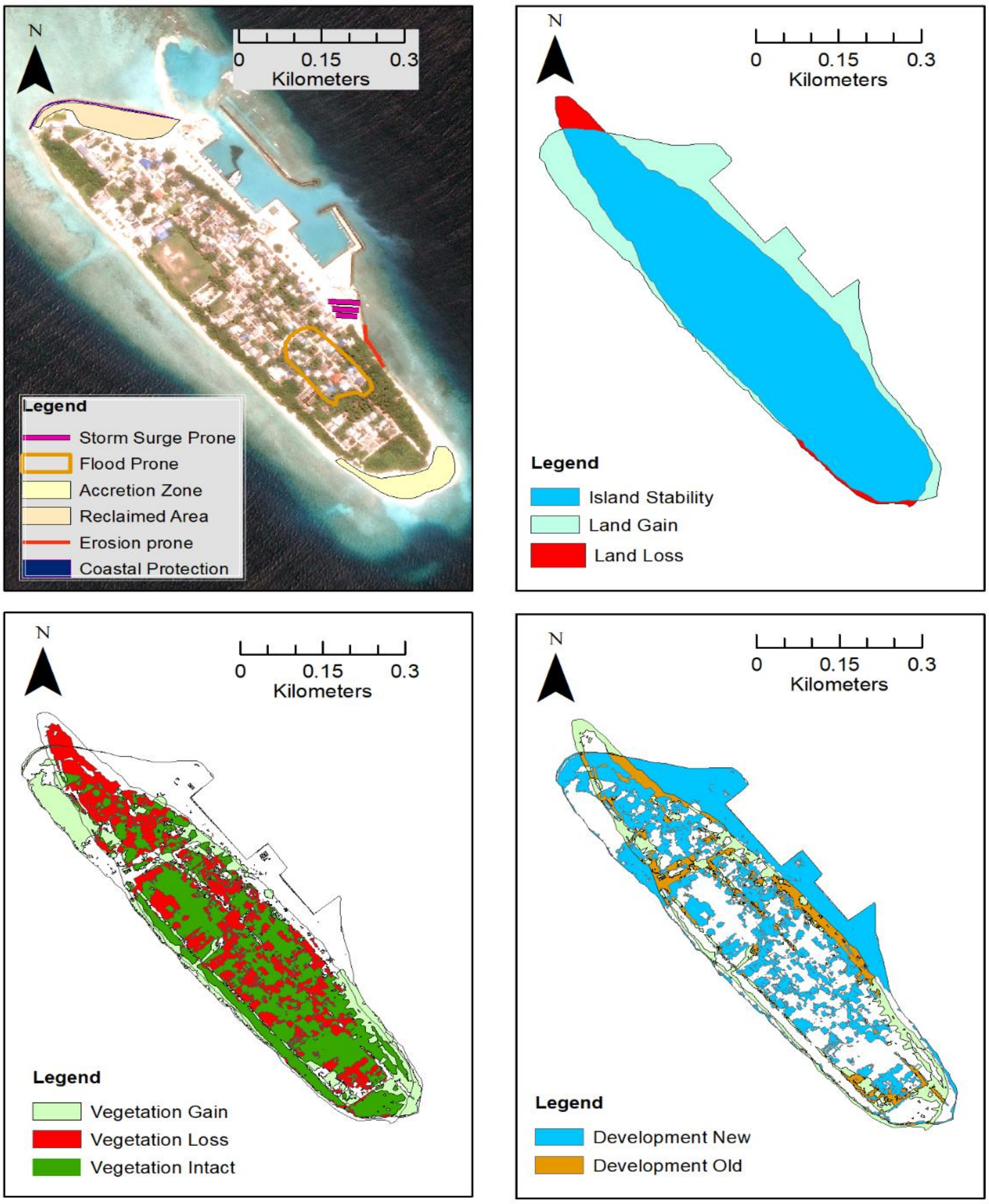
The results showed that in 1969, the island was 7.7 hectares in size, based on the EVL. The area of development was 1.5 hectares, while intact vegetation cover was 6.3 hectares. The island has lost about 0.2 hectares from the SW side over the 47 years, while a net gain of 2 hectares was observed. The urban boundary has expanded from 1.3 hectares to about 6.3 hectares, increasing urban sprawl by 76 percent over the past 47 years. This has caused a loss of vegetation by 95 percent. In 2017, the island underwent another reclamation on the SW coast line of the island. The reef hosting the island is circular and is about 37 hectares in size (Figure 6.4).



27. Figure 6.4 Analysis for Bodufolhudhoo showing island characteristics (top left), and changes in morphology (top right), vegetation (bottom left) and development (bottom right)

6.5.2 Ukulhas

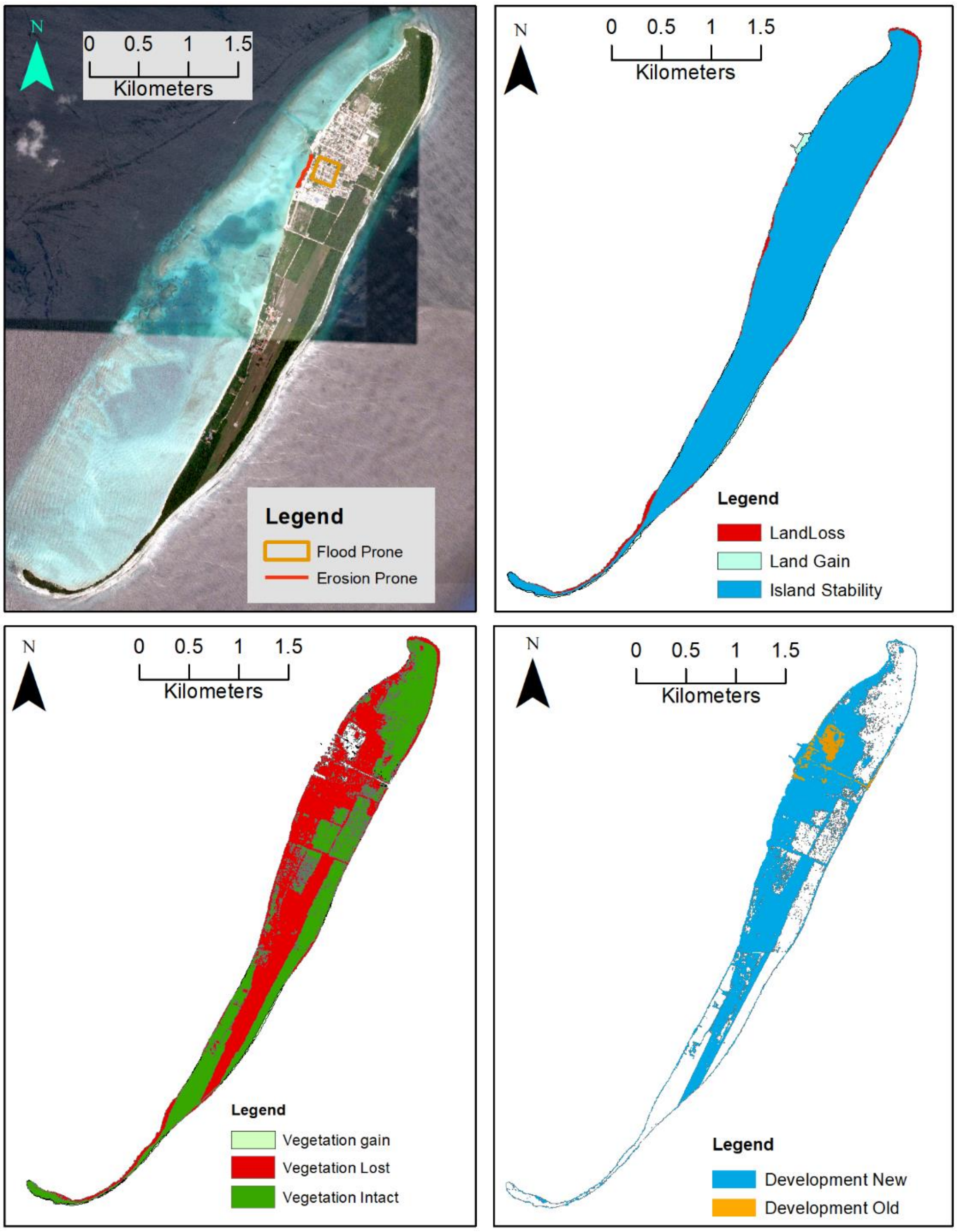
The size of Ukulhas was 16.5 hectares in 1969, with a development footprint of 4.3 hectares, and vegetation cover in 1969 was 12.2 hectares. A land loss of 0.5 hectares has occurred within the last 47 years, while a net gain of 5 hectares of land was observed, mainly due to reclamation of the coast line. By 2017, the island size has increased to 21 hectares, while the urban boundary has expanded by 58.65 percent to 10.4 hectares. Compared to 1969 about 13 percent of vegetation was lost by 2017. The island is hosted by an elongated reef with an area of 58 hectares (Figure 6.5).



28. Figure 6.5 Analysis for Ukulhas showing island characteristics (top left), and changes in morphology (top right), vegetation (bottom left) and development (bottom right)

6.5.3 Hanimaadhoo

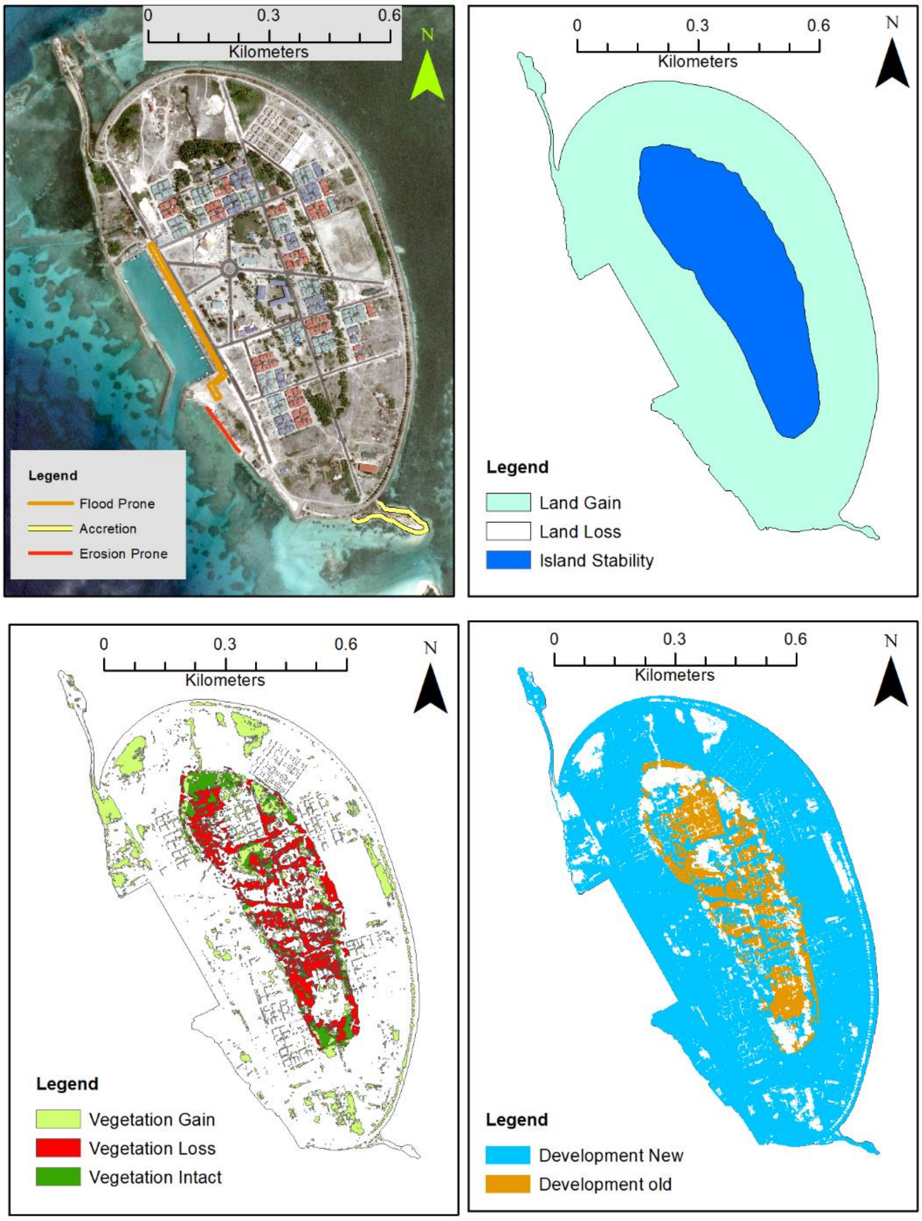
Hanimaadhoo had a land area of 296 hectares in 1969, based on EVL. By 2017, the area was reduced to 292 hectares. The result was a net loss of 3.9 hectares of land by 2017. The development footprint of Hanimaadhoo was only 8.8 hectares in 1969, but has increased by 93.4 percent over the past 47 years to 124.8 hectares. Intact vegetation was 287 hectares in 1969, while it was reduced to 158 hectares by 2017. The host reef of the island is elongated and is 779 hectares in size (Figure 6.6).



29. Figure 6.6 Analysis for Hanimaadhoo, showing island characteristics (top left), and changes in morphology (top right), vegetation (bottom left) and development (bottom right)

6.5.4 Vilufushi

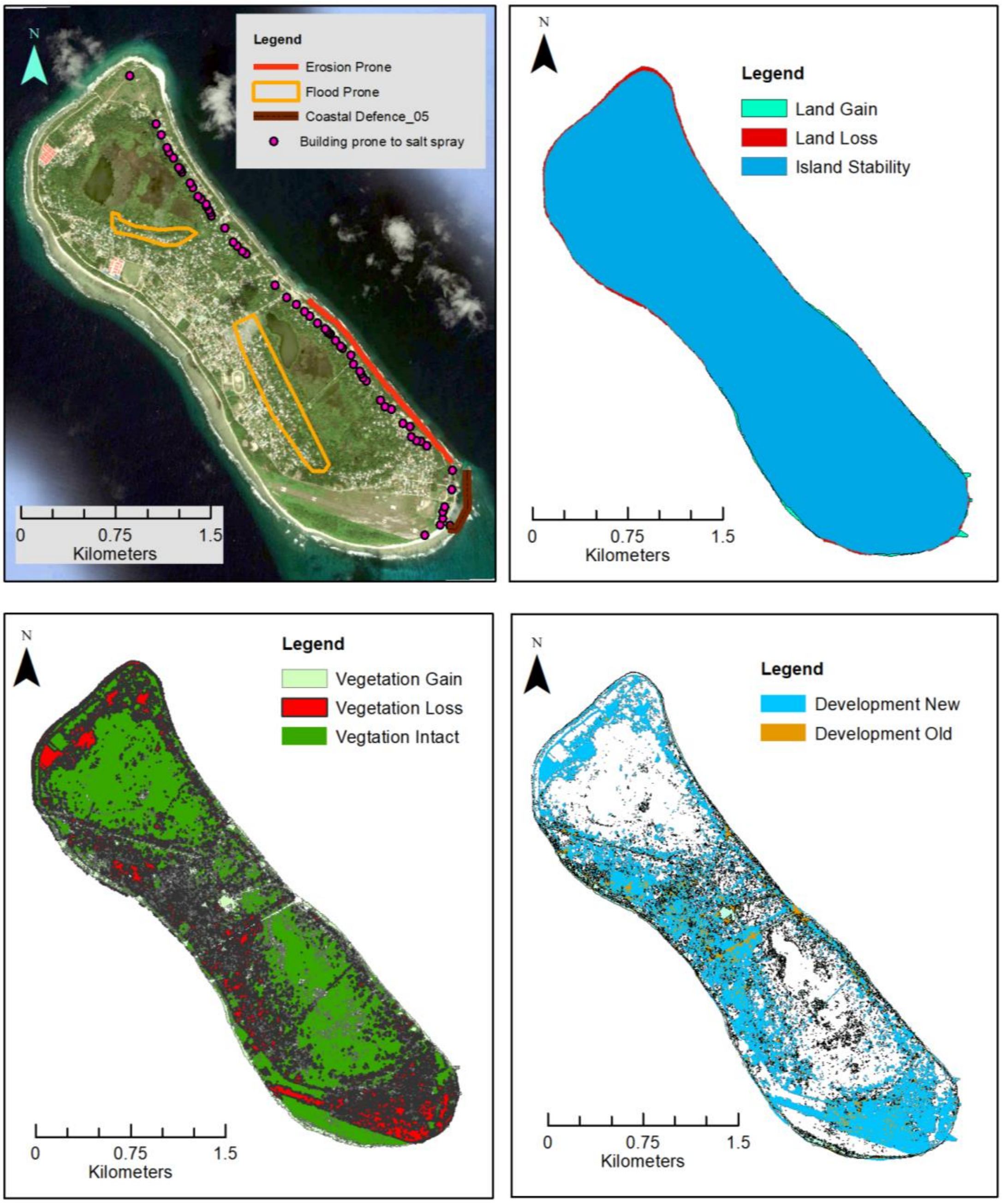
Villufushi has undergone huge land gain since 1969. The size of island in 1969 was 15 hectares and in 2017 it was 58.5 hectares. The size of development foot print in 1969 was 8.1 hectares and vegetation cover was 7 hectares. By 2017, vegetation cover has increased to 8.2 hectares and urban boundary expanded to 50.2 hectares. There was no net loss in land, but a gain of 288 percent. The island is situated in the rim reef of the atoll with five other islands. The surrounding reef area of the island excluding other bigger islands is 105 hectares (Figure 6.7).



30. Figure 6.7 Analysis for Vilufushi, showing island characteristics (top left), and changes in morphology (top right), vegetation (bottom left) and development (bottom right)

6.5.5 Fuvahmulah

The area of Fuvahmulah, based on EVL, was 487 hectares in 1969. By 2017, the area was 484 and land loss of 7.5 hectares and land gain of 3.5 hectares was observed over the past 47 years. Consequently, a net loss of 3.7 hectares of land was seen. The urban boundary expanded from 57.8 hectares in 1969 to 158.3 hectares by 2017. Vegetation cover, including swampy wetlands, was 428.7 hectares in 1969. However, intact vegetation cover was reduced to 325.3 hectares by 2017. The reef area of the island is 779 hectares (Figure 6.8).



31. Figure 6.8 Analysis for Fuvahmulah, showing island characteristics (top left), and changes in morphology (top right), vegetation (bottom left) and development (bottom right)

6.6 Physical and natural barriers and limits on islands

The results indicated that all islands have undergone drastic changes in land use and urbanisation during the past 47 years. All islands had a very small development footprint and were rural in nature, according to 1969 images. The Maldives has undergone dramatic land use changes in recent decades, mainly due to poor urban planning and population increase (Fallati et al., 2017). The biggest loss in land from coastal erosion was observed in Hanimaadhoo, followed by Fuvahmulah; but, Ukulhas and Bodufolhudhoo also lost land. In addition, the net change in land was negative for Hanimaadhoo and Fuvahmulah, where loss was higher for Hanimaadhoo. On all other islands, net change in land was positive, with Villufushi gaining land by an increase of 280 percent, Ukulhas by 20 percent, and Bodufolhudhoo by 19 percent. Vegetation cover was reduced on all islands except Villufushi. The largest loss in vegetation occurred in Bodufolhudhoo, followed by Ukulhas. Urban expansion was highest in Villufushi, followed by Bodufolhudhoo. According to field observations and PCCAA results, deterioration of the freshwater lens is most critical for Bodufolhudhoo, followed by Ukulhas. The small width and area of both islands exacerbates the deterioration of freshwater lens. Freshwater salinization was of least concern in Fuvahmulah, followed by Vilufushi. Based on both freshwater lens deterioration and land degradation due to urban expansion, the biggest impact was observed in Bodufolhudhoo, followed by Ukulhas. Fuvahmulah had the least degradation, followed by Hanimaadhoo. Vilufushi is an exceptional case, as the island has been completely rebuilt after being destroyed by the 2004 Indian Ocean tsunami. Land gain in islands was due to reclamation by borrowing sand from nearby lagoons or shallow reefs.

All study islands were characterised by low-lying flat topography, vulnerable coastal hydrodynamics, and deficiency in freshwater and land. Hence, the islands are vulnerable to flooding from rain and storm surges, as well as other climatic stresses, such as increasing temperature and droughts. The major barriers and limits are:

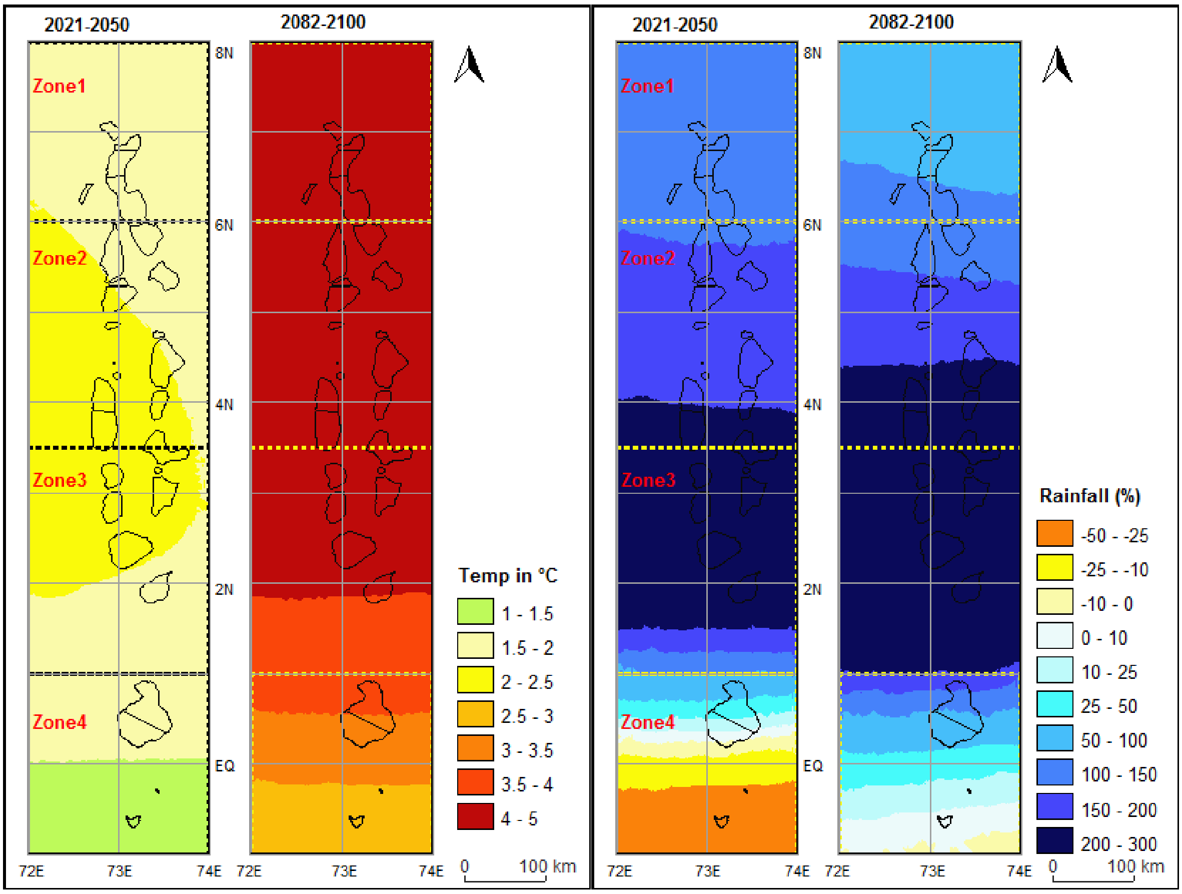
- Vulnerability to multiple stresses
- Exposure to climate variability
- Land availability
- Size and population density
- Remoteness
- Natural resources
- Ground fresh water resources
- Environmental Degradation

6.6.1 Vulnerability to multiple stresses

All islands face multiple climatic and non-climatic stresses, exacerbated by climate change impacts, as discussed in Chapter five of this thesis. Major stresses include flooding due to rain, temperature increase, drought, coastal erosion, storm surges, and short bursts of intense rain. Except in Vilufushi, all other islands experience three or more climatic stresses per year as a consequence of the direct impacts of climate change. In Vilufushi, only temperature increase and prolonged droughts are experienced annually. In terms of vulnerability to multiple stresses, Vilufushi faces the least, while Ukulhas faces the most.

6.6.2 Exposure to climate variability

Exposure to climate variability, based on gridded zones in a downscaled regional climatic model developed by MEE, showed that the five case study islands falls within the four gridded zones in the model (Figure 6.9) (MEE, 2015a). Hanimaadhoo falls within zone one, and Ukulhas and Bodufolhudhoo are in zone two. Vilufushi is in zone 3, while Fuvahmulah is in zone four. This model indicated slight variations in temperature increase and rainfall. While zones 1-3 are expected to have more intensified temperature increases and rainfall, zone four is expected to have less. By 2100, zone four is expected to have an increase in temperature range of 2.5 to 4 ˚C. However, in zones 1-3, the increase is expected to be between 4 and 5 ˚C, compared to the 1980 to 2000 baseline. Rainfall is expected to increase by 50 to 150 percent for zones one and four. Meanwhile, zones two and three will have an increase of 150 to 300 percent in rainfall by 2100 compared to 1980 to2000 baselines. These predictions indicate increase in temperature and flooding from rain will exacerbate in future for all islands. All islands except Fuvahmulah will face higher increases in temperature, according to this model's predictions, as stated in the Second National Communication of the Maldives to UNFCC. Additionally, flooding risk is lower for Fuvahmulah and Hanimaadhoo, compared to others, as indicated by this model. Regarding inundation risks from sealevel rise and sea surface heights, based on the worst-case scenarios for 2080, the model indicated that the highest inundation percentage was for both Ukulhas and Bodufolhudhoo with 6.5 percent, followed by Vilufushi with 5.09 percent, and Hanimadhoo with 2.67 percent of land. Fuvahmulah has the lowest inundation percentage compared to current dry land and is predicted to be only 0.81 percent by 2080. Consequently, among the case study islands, Fuvahmulah has the lowest exposure in terms of rainfall intensity, temperature increases, and inundation of dry land from sea level increase, followed by Hanimaadhoo. The highest risks are for Bodufolhudhoo and Ukulhas, while Vilufushi is predicted to face a moderate exposure to rainfall intensity, temperature increase, and inundation.



32. Figure 6.9 Zonal variations for the four zones, showing temperature (left) and rainfall (right) over the Maldives domain

From IPRC Regional CM scenario time slices (2021-2050 and 2082-2100) from the baseline (1980-2000), adapted from (MEE, 2015a)

6.6.3 Land availability

The land use pattern for the entire Maldives was determined by a high resolution image analysis of entire Maldives and showed that urban area was 5,918 hectares in 2011 (Fallati et al., 2017). Among the case study islands, Fuvahmulah is the largest island with 484 hectares, followed by Hanimadhoo with 292 hectares. The third largest is Vilufushi with 58.5 hectares. The smallest island is Bodufolhudhoo with 10.5 hectares, while Ukulhas is 21 hectares. The results from PCCAA mapping exercises indicated that land availability was the most significant limit for Bodufolhudhoo, followed by Ukulhas. Even though Fuvahmulah has the largest land area, most of the vacant land is within or adjacent to the swampy freshwater wetlands. Hence, land may become a major limit in future, especially due to the lack of shallow reef area for reclamation in Fuvahmulah. In all islands, urban expansion continues within the entire island, while in Bodufolhudhooa and Ukulhas, the distance between infrastructure and the shoreline is less than

20 metres around the whole island. On all other islands, buildings closer than 20 metres to the shoreline are less common, as densification near the shoreline is low. Vilufushi has undergone a major reclamation and is currently undergoing planned housing schemes with no private land available for housing plots and, thus, land availability is not considered a limit. Reclamation potential was analysed using the available shallow lagoon and reef area. The analysis indicated Hanimaadhoo has the largest shallow lagoon available, where about 350-400 hectares can be reclaimed, followed by Bodufolhudhoo with a potential of about 30 hectares. Ukulhas has already undergone minor reclamation alongside the harbor and has about 20 hectares of shallow lagoon which can be reclaimed. The current cost for reclamation varies from US$ 165-170 thousand per hectare and reclamation projects have been undertaken in at least 10 islands over the past five years. In Bodufolhudhoo, lack of land is a major biogeophysical limit for adaptation capacity, as the urban expansion of the island has reached to the edge of the island, leaving only a thin strip between home plots and the shoreline. Consequently, the island has reached the limits whereby the vulnerability and exposure to storm surges and floods has become a major constrain for adaptation. The analysis demonstrates profound modifications in land use in all the case study islands owing to increases in population. However, with the exception of Bodufolhudhoo and Ukulhas, all other islands currently have sufficient land to build adaptation related infrastructure to maintain climate stresses within acceptable levels. As shown by this analysis, land area in both Bodufolhudhoo and Ukulhas have becoming a major limit due to population density and demand for new plots for infrastructure.

6.6.4 Size and population density

The population density was determined for the entire nation, based on land area and the population of all inhabited islands according to the DNP (2014) Census. Malé and islands in the immediate vicinity of Malé were excluded, considering Malé as an exception, due to extremely high population density. Even though the population has tripled in the last 40 years, the growth rate of the Maldivian population has decreased to 1.82 percent and is slightly above the world population growth rate of 1.14 percent (based on 2014 data) (DNP, 2015). The population density, based on the area of 186 inhabited islands, excluding Malé and islands in near the city, is 16 persons per hectare, or 1,664 persons per square kilometres. According to the results from the case study islands, population density is highest for Bodufolhudhoo with 56 persons per hectare, followed by Ukulhas with 44 persons per hectare. The lowest population density was for Hanimaadhoo with six persons per hectare. Both Vilufushi and Fuvahmulah have about 16 persons per hectare. Population density compared to national average indicates that both Bodufolhudhoo and Ukulhas have highest densities with 55 and 44, respectively, and without reclamation the islands cannot sustain urban expansion, even with modest population growth rates.

6.6.5 Remoteness

Remoteness is not a major concern in any of the case study islands. Even though, Fuvahmulah is isolated from other atolls, the island has an airport and is linked to the nearby atoll by ferry. Hanimaadhoo also has an international airport and is the major transport hub of the north. Hence, remoteness is not a limit for Fuvahmulah and Hanimaadhoo. However, remoteness is high for Ukulhas, Vilufushi and Bodufolhudhoo, as they rely on sea transport via public ferries or private ferry operators. Both air and sea transport are affected by climate related stresses, such as stormy weather. For instance, while heavy rain and flooding can disrupt sea transport, air travel is also often disrupted in stormy weather. Additionally, major transport infrastructure, such as ports and airports, are equally vulnerable to inundation from flooding due to rain or seawater intrusion, as the height of such infrastructures is at the ground level of the islands, with a maximum height of three metres above mean seal level. Residents from all islands, except Fuvahmulah, reported facing shortages in food availability during stormy weather, as food supply is dependent on sea transport. However, participants from Fuvahmulah indicated that they still heavily rely on the taro as a staple food, especially when imported foods are in short supply.

6.6.6 Natural resources

On all islands, natural resources are coastal marine based. The major coastal marine resources are the coral reefs and associated marine habitats. The total coral reef area of the Maldives is 44,938 hectares (Naseer & Hatcher, 2004). In addition, wetlands are also important natural resources, as they provide major ecosystem services including extractive resources. All islands have coral reefs and the area depends on the island physio-geography. For instance, islands on atoll rim reefs have a larger reef area, while faro islands have smaller reef areas. Except for Fuvahmulah, which is an oceanic island isolated from a major reef system, all other islands had proportionally large reef areas and shallow lagoon areas in the immediate vicinity of the islands, and are common pool resources shared equally. The reef area of Hanimaadhoo is the largest and is 779 hectares, followed by Fuvahmulah with 472 hectares. Bodufolhudhoo has the smallest reef area and is 37 hectares, followed by the second smallest, Ukulhas, with 58 hectares. Villufushi has a long stretch of reef as the island is situated on the atoll rim reef. However, the reef area of Vilufushi was determined as the edge of the boundary of the nearest inhabited island, and the area calculated was 105 hectares. Hence, baitfish grounds and reef resources were within the proximity of most islands. Fuvahmulah is an oceanic island separated from other atolls and, therefore, has no other islands or reefs in the immediate vicinity. In the recent years, local island tourism has become a major source of revenue for Hanimaadhoo, Ukulhas, and Bodufolhudhoo. From the five case study islands, the only islands with wetlands are Hanimaadhoo and Fuvahmulah. Hanimaadhoo has a small wetland area without a permanent water body, but gets filled during the rainy season and remains as a swampy area with few true mangroves and other associated flora. Fuvahmulah is the only island with notable freshwater, swampy wetlands. On all islands, the most scarce natural resources are freshwater and land, owing to their small size and geomorphology (Bridges & McClatchey, 2009). Freshwater and land availability are a major barrier for Bodufolhudhoo, followed by Ukulhas.

6.6.7 Ground freshwater resource

One of the most vulnerable resources in the islands is ground freshwater. The freshwater lens is prone to changes in future rainfall, extraction, sea level rise, and contamination (Deng & Bailey, 2017). The thickness and sustainable yield of the freshwater lens was determined by the methodology given by Bailey, Jenson, and Olsen (2010);Bailey et al. (2015), and Deng and Bailey (2017) , and the lens area and recharge rate was determined according to (Falkland, 2001) (Table 6.2). Island width was based on 2017 Google Earth imagery of the islands and rainfall data was obtained from the National Meteorological Service database.

18. Table 6.2: Freshwater related parameters for study islands

Island	Island width at maximum (metres)	Average freshwater lens thickness at maximum (metres)	Average rainfall (mm/year)	Annual recharge volume (Cubic metre)	Annual safe yield (Cubic metre)
Bodufolhudhoo	350	2.95	1950.5	2503.5	751.05
Ukulhas	250	1.78	1950.5	5007.0	1502.1
Hanimaadhoo	750	9.17	1750.0	156000.8	46800.2
Vilufushi	500	5.36	1950.0	35049.0	10514.4
Fuvahmulah	1200	13.35	2300.3	371338.5	111401.5

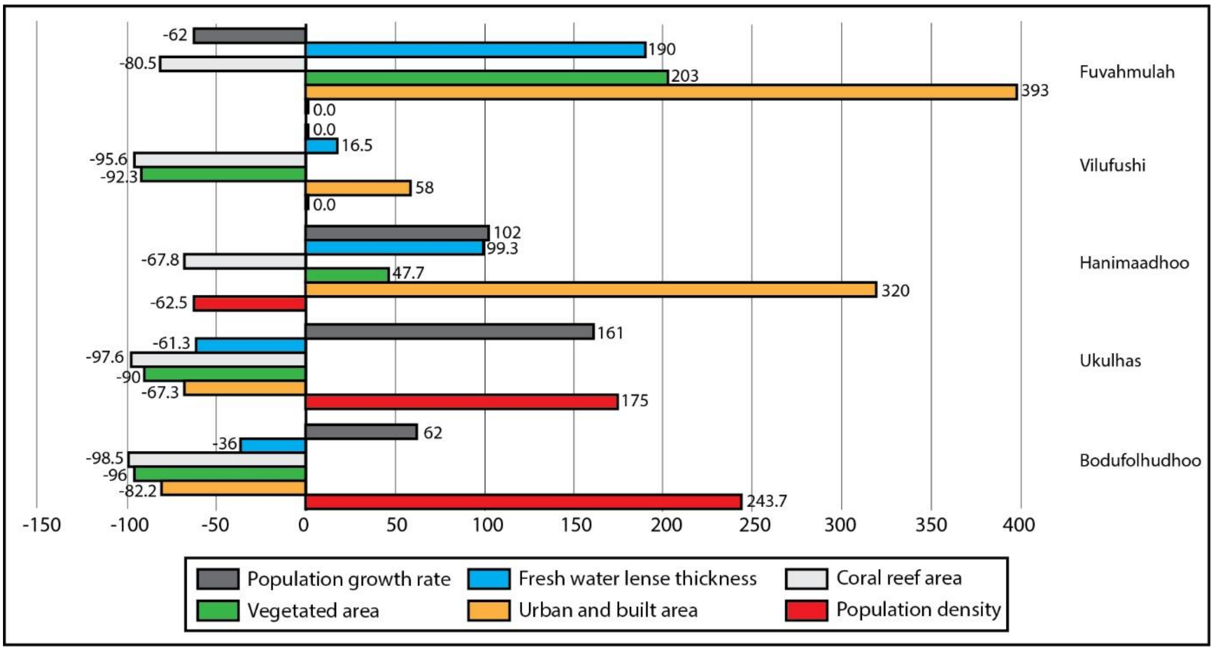
According to these data, the freshwater lens in Bodufolhudhoo and Ukulhas are highly vulnerable to depletion, and PCCAA results also showed people experiencing increased salinization of the ground water, especially between January and May. The data show freshwater lens thickness is directly influenced by rainfall (in addition to island width and size) and, thus, a decrease in lens thickness from south to north is observed in the Maldives (Deng & Bailey, 2017).

6.6.8 Environmental degradation

Major environmental degradation on the islands is related to unsustainable urbanisation and coastal modifications. According to the present analysis, urban expansion in 2017, compared to 1969, is highest in Vilufushi followed by Bodufolhudhoo. The higher percentage for Vilufushi is due to reclamation of the island, and an increase in size of the island from 15 hectares to 58.5 hectares. Bodufolhudhoo has highest urban expansion followed by Ukulhas. The least urban expansion was seen in Fuvahmulah, followed by Hanimaadhoo. Consequently, Fuvahmulah has the least level of land degradation and vegetation loss compared to other islands. However, field observations indicated major threats to the island of Fuvahmulah due to coastal erosion.

6.6.9 Comparison of biogeophysical features of islands with entire country

To compare the biogeophysical features and population of the islands, the national average for entire country was determined. In the analysis, Malé and islands in the greater Malé region, including Villimalé and Hulhlumalé, were excluded. The area of the islands was determined based on the size of 186 inhabited islands in 20 atolls of the Maldives, according to DNP 2014 census data. The total area of 186 inhabited islands (excluding Malé and islands nearby) was 12,563 hectares. The vegetated area and urban area were determined based on high resolution image analysis of entire Maldives by Fallati et al. (2017). According to Fallati et al. (2017), based on 2011 satellite imagery, the total urban and developed area of the 1,190 islands of the Maldives was 5,918 hectares, and the total vegetated area was 19,948 hectares. In the analysis, wetlands and agricultural plots were regarded as vegetated areas. The population density for the entire country was determined by using the area of 186 inhabited islands and population of those 186 based on DNP (2014), and was 16 people per hectare. Population growth rate was based on the DNP (2014) census data. The growth rate for Vilufushi was 40.8 as the island was evacuated during the 2006 census, and re-populated by the next census in 2014. Hence, the national average of 1.8 was considered for Vilufushi to avoid inflation of data. As there are no data on average freshwater lens thickness for all inhabited islands, the analysis was based on the average lens thickness for 55 inhabited islands, calculated by Bailey et al. (2015), where the lens thickness was observed to be 4.6 metres. The results of the comparative analysis as a percentage compared to the country average are provided in Figure 6.10.



33. Figure 6.10 Comparison of various biogeophysical features of islands with the country average

According to this analysis, Bodufolhudhoo and Ukulhas have all features below the national average, except for population density and population growth rate. The population density of Bodufolhudhoo was 243.75 percent higher than national average, while in Ukulhas it was 175 percent more. However, compared to the national average the population growth rate was highest for Ukulhas, at 160.9 percent, while Bodufolhudhoo had the third highest with 62 percent of the national average. In Fuvahmulah, population density was the same as the national average, while in Hanimaadhoo it was below national average with 62.5 percent, compared to national average. The only island with a negative population growth rate was Fuvahmulah with 62 percent lower than national average. Freshwater lens thickness was highest above the national average for Fuvahmulah, followed by Hanimaadhoo and Vilufushi. Land area was also highest above the national average for Fuvahmulah, followed by Hanimaadhoo and Vilufushi. Vegetation was also highest above the national average for Fuvahmulah followed by Hanimaadhoo, as both islands have larger land areas compared to national average. In all other islands, land area and vegetation cover were below national average.

6.7 Discussion

This discussion is based on the biogeoophysical barriers and limits and thresholds in relation to climatic stresses, coupled with anthropogenic factors. A threshold was considered as a boundary within a specific spatial and temporal dimension which, when surpassed, causes intractable irreversibility within the system, compelling exogenous interventions for the sustainability of the system (Friedel, 1991; Levin & Clark, 2010). The thresholds detected are based on land loss, vegetation loss, urban expansion, destabilisation of coastal zone, deterioration of freshwater lens, and coastal marine resources in the islands. For example, the temporal change in freshwater lens from a non-saline to saline, natural land accretion to land loss or urban expansion from sustainable to an unsustainable state, and from a steady state equilibrium of coastal dynamics to destabilised coastal dynamics. These thresholds are regarded as dynamic as their position can shift based on the synergies and trade-offs with the biogeophysical environment and development, and their capacity to buffer climatic stress (Levin & Clark, 2010).

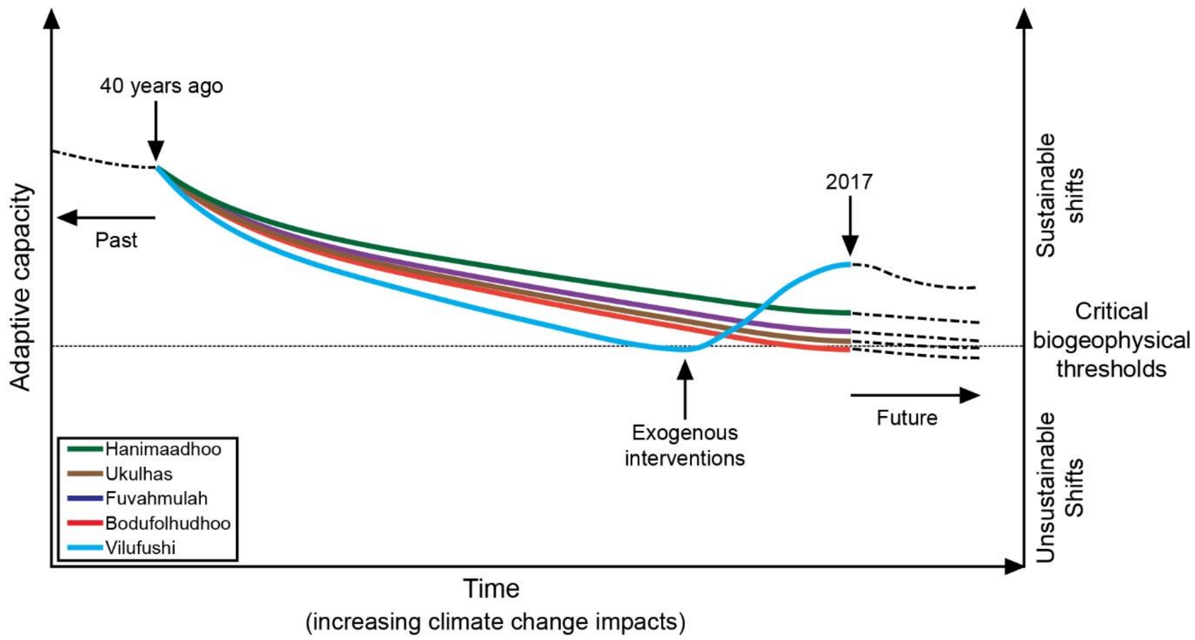
Turton (1999) developed conceptual models to describe how changes in the level of environmental capital influence adaptive capacity. Similarly, a model depicting the influence of various levels of risks in relation to adaptation limits was provided in (Dow et al., 2013). Based on the relevant literature case study islands were grouped into three distinct types (**a, b,** and **c**) (Jones, Ludi, & Levine, 2010a; Levin & Clark, 2010; Walker & Meyers, 2004). These three groupings were based on levels of changes in: land loss; vegetation loss; urban expansion; freshwater lens salinization and synergies; and trade-offs with biogeophysical factors in their contexts and configurations within the islands. The first type, **(a)**, as shown in Figure 6.11, are safer islands which are completely built from scratch or rebuilt, after the threshold levels of climatic stresses or other natural events decreased into intractable limits, shifting the biogeophysical features of the island. In this island type, the threshold of barriers and limits are halted by substituting the natural adaptation capacity with exogenous engineered adaptation. Consequently, the island's adaptive capacity is increased and sustained at a steady state. However, the natural stability of islands is lowered and, hence, may require continuous mobilisation of exogenous interventions. In the second type, **(b)**, the adaptive capacity slowly decreases, but is maintained at a steady equilibrium state within the threshold limit. In these islands, climatic stressors, coupled with anthropogenic impacts, have not yet decreased below the lowest threshold. Hence, these islands are in a dynamic equilibrium with biogeophysical limits. In these islands, urban expansion has undermined natural stability and, therefore, requires interventions to enhance the adaptive capacity before the threshold surpasses the tolerable level. The final type, **(c)**, is an island where the natural limit is under the threat of falling below the tolerable natural threshold. The island is at the lowest end of the biogeophysical threshold. Consequently, the island may no longer have the capacity to reduce its vulnerability even if engineered exogenous interventions of prohibitively high costs are mobilised. The options for such islands are to either relocate the communities, or to undergo hard engineering solutions, with overwhelming costs outweighing the benefits of such interventions.

The present analysis showed that Vilufushi is an island of type **a**, as the island has undergone multiple exogenous interventions. Prior to the exogenous hard engineering adaptations, the island was at the lowest thresholds of biogeophysical limits. For instance, population density was 100 persons per hectare, with a scarcity of land and a lack of vegetation (NDMC, 2009). In addition, the island was exposed to multiple climatic stresses, such as rainfall flooding and storm surges, even though major losses or damages in terms of human lives or infrastructure were limited. The rebuilding of Vilufushi included reclamation of land and elevating the island by +1.4 metres above the mean sea level (NCEA, 2005). In addition, an Environmental Protection Zone 2,020 metres in length, covering the east, north and south of the island, was raised to +2.4 metres above mean sea level (NCEA, 2005). This coastal revetment also included an artificial ridge made of granite boulders. These exogenous interventions increased the adaptive capacity of the island, allowing sustainability of the biogeophysical thresholds well above intolerable levels. Though the island does not have any biogeophysical limits, the natural stability of the island is lowered. For instance, the soil in the island has become deficient in nutrients leading the natural succession of vegetation in the island at risk. Although the island does not experience storm surges, the newly dredged harbor basin is influenced by stormy weather, making the harbor unsafe for vessels. PCCAA also indicated that the harbor front area next to the quay wall accumulates water during heavy rainfall. Additionally, people have identified the urban island heat effect causing a relatively higher increase in temperature and humidity on the island.

Fuvahmulah and Hanimaadhoo fit in to type **b**, where the islands' adaptive capacity is within the biogeophysical threshold sustainability level. The islands are at a critical juncture where further increase in climatic stresses, coupled with anthropogenic effects, can easily surpass this level to intolerable thresholds. In these islands, vegetation is still intact providing coastal setbacks and urbanisation is within acceptable levels due to lower population density.

However, the islands require exogenous interventions to different extents. Fuvahmulah urgently requires coastal protection and improvements in existing flood mitigation structures. Compared to Fuvahmulah, Hanimaadhoo does not have critical biogeophysical limits that require urgent exogenous interventions; however, with predicted climate change impacts for 2080, all islands must undergo engineering adaptations. Even though Vilufushi is developed as a safer island, the adaptation features incorporated within the designing of the island may not be able to reduce exposure to certain climatic stresses, such as flooding from intense rain or temperature extremes.

Bodufolhudhoo and Ukulhas belong to type **c**, and are at a lower threshold, where major natural limits have surpassed the ability of the island to reduce vulnerability, even with major adaptations. For instance, the lack of land and degradation of freshwater lens have surpassed the capacity of Bodufolhudhoo to remain within the sustainable biogeophysical limits. With the predictions of future temperature extremes, rainfall variations, and inundation risks, Bodufolhudhoo and Ukulhas may surpass natural thresholds, resulting in even more limits in terms of availability of land, freshwater and arable soil. The proximity of homes and infrastructure to shoreline also adds to the adaptation limits of Bodufolhudhoo. Hence, the costs of mobilising any exogenous interventions are prohibitively high, and outweigh the benefits. Ukulhas has undergone coastal protection and reclamation in 2017, and has a desalination plant supplying piped drinking water. However, as the desalination process is powered by using fossil fuels, the price of water is extremely high. Participants in PCCAA indicated that they find it too expensive and, hence, must rely on rain water harvesting. However, Ukulhas has a higher capacity to adapt to coastal erosion and water stress from climate change perturbations, compared to Bodufolhudhoo.



34. Figure 6.11 Islands categorised according to adaptive capacity limits and thresholds

The major trade-offs made with natural factors, in the study islands are exogenous interventions, substituting natural stability of the islands with engineered adaptations. For instance, coastal revetments, raising the island above sea level, and construction of infrastructure, such as networks for water and sewerage services are observed in some islands. Many hard engineering measures for coastal protection cease to provide a natural retreat of shoreline and accommodation space for islands to grow outwards, causing major disruptions in the natural, steady equilibrium of the coastal zone (McLean & Kench, 2015; Sovacool, 2011). Such hard engineering measures arise, in part, due to the discourse of engineering resilience, where the capacity of the system to bounce back to its original state is paralleled with engineered adaptation (Davoudi et al., 2012). Such strategies also arise due to framing of adaptation policies within a risk management viewpoint (Davoudi et al., 2012). For instance, in the Maldives, the discourse on adaptation has been framed, planned, and implemented as risk mitigation (Malatesta & Schmidt di Friedberg, 2017), rather than through transformative adaptation. Consequently, the emphasis on the dynamic natural equilibrium of socio-ecological systems is undermined. Such framing also has the notion that profound transformations in a socio-ecological system is a failure, rather than a critical opportunity to enhance natural resilience (Davoudi et al., 2012). As Davoudi et al. (2012, p. 304) stated, this paradigm undermines the fact that that people become resilient "not in spite of adversities but because of them". Hence, a linear focus on understanding risks and adapting to them through reactive, event driven strategies, to return to a steady level as quickly as possible, lacks the fundamental principle of resilience being dynamic in nature (Davoudi et al., 2012). Consequently, a paradigm shift from adaptation as an end, to a dynamic transformative process, must take place to enhance transformative adaptation strategies and policies.

According to the analysis of case study islands, Vilufushi has undergone major hard engineered adaptations to the specifications of the Safer Island Strategy of the Maldives (NCEA, 2005). No other study islands have coastal revetment, though all islands have a seawall around the harbor and minor reclamations adjacent to the harbor, carried out during dredging for harbours. The costs of such engineered solutions are prohibitively high. For instance, the total cost for reclamation and coastal modification on the island of Vilufushi was US$19 million (NCEA, 2005). Reclamation costs at current levels are US$160-180 thousand per hectare, according to reports from the Ministry of Housing and Environment. However, reclamation is a reactive, event-driven measure to address land scarcity. Consequently, reclamation in some islands has exacerbated climatic stresses, such as flooding. For instance, the island of Meedhoo, in the Dhaal Atoll, reclaimed some land in 2016, but recently got flooded by heavy rainfall (Shifleen, 2017). The islanders experienced a one-metre-high flood level in the non-reclaimed area, as the water from reclaimed area ran off in to lower unreclaimed parts (Shifleen, 2017). This flooding indicates that reclamations carried out without proper strategic adaptations to mitigate flooding results in maladaptation. Similarly, Vilufushi is also vulnerable to flooding from rainfall as the drainage features planned to be constructed between the original island and newly reclaimed area were never built (UNDP, 2008). Additionally, topographic changes from urbanisation and lower hydraulic conductivity of carbonate material in reclaimed areas can exacerbate flooding (UNDP, 2008). Consequently, the hard adaptation interventions in Vilufushi may have reduced the ability of the island to respond to certain climatic stresses like flooding.

All islands, other than Vilufushi, have also undergone some hard engineering adaptations. For instance, paving of roads and drainage systems in Fuvahmulah were considered critical to reduce impacts from flooding. The PCCAA exercises from Fuvahmulah indicated that the drainage systems are not effective and require major renovations as the systems are old and lack the capacity to remove storm water from the island. People also mentioned the poor design of some roads, as they block the water movement within the swampy wetlands in the island, resulting in runoff into urban areas. Another major issue was the blockage of a main drainage channel due to the construction of the airport. Hence, poor infrastructure planning and design was a major trade-off limiting adaptation to flooding in Fuvahmulah.

Both the Ukulhas and Hanimaadhoo PCCAA indicated exacerbation of erosion due to harbor construction. While Ukulhas required major coastal protection due to continued erosion, Hanimaadhoo does not face such rapid erosion, even though the net effect was a loss of 3.9 hectares from Hanimaadhoo over the past 50 years. However, participants viewed that without a well-timed intervention, erosion levels reduce the threshold of the sustainable limit. Hanimaadhoo participants also mentioned unsustainable urbanisation expansion within the lowest area of the island, causing increased vulnerability and exposure to flooding. While the net effect on Fuvahmulah has been a loss of 3.7 hectares of land over the last 50 years, the island is considered more vulnerable and in imminent danger of coastal destabilisation. In all islands, land loss due to erosion has been offset by both reclamation and accretion. In Vilufushi, accretion is low as the island is surrounded by a revetment, preventing any natural accretion. McLean and Kench (2015) found that accretion of islands will be reduced when the sediments around the islands are permanently lost due to them being moved out of reef into deep water. In our case study islands, this could hold true to some extent for Fuvahmulah, as the distance between the reef area of the island and deep water is very narrow. However, the majority of sediment loss in the case study islands is due to extensive coral and sand mining from beaches and lagoons, in the past. Additionally, the islands have little accretion, even though a net increase in land was observed for some, due to reclamation. Consequently, the seasonal changes in island shorelines and erosion patterns are mostly influenced by synergies of natural and anthropogenic factors and trade-offs with development and environment. Hence, as found by McLean and Kench (2015), the influence of sea level rise on coastal land loss is less, compared to these synergies and trade-offs.

Coastal modifications on study islands included common interventions found in the Maldives, except offshore breakwaters. The most common coastal modification was basin harbours found on all islands, followed by shore parallel structures (both protruding outwards and adjacent to shoreline) and coastal revetments. In Vilufushi a coastal revetment surrounds the majority of the island and is parallel to the shoreline of reclaimed island. As found by Kench (2012), the terminal end of revetment shows instability in Vilufushi. However, the unprotected eastern parts do not undergo accelerated uniform erosion, even though rapid seasonal changes are observed. Additionally, the southern end of Vilufushi has a line of small islands buffering the effect of longshore currents. The basin harbours in all islands, except Fuvahmulah, show instability, with more destabilisation on the proximity of the harbour. For instance, in Hanimaadhoo, Ukulhas, and Bodufolhudhoo, coastal erosion is observed due to disturbance in longshore currents and sediment transport. For instance, in Ukulhas and Hanimaadhoo, the down drift side of harbour basin experiences erosion, while the up-drift side has sediment accretion. In Ukulhas, erosion is observed on both sides of the harbour, while in Hanimaadhoo it was on the southern side only. In Bodufolhudhoo, erosion is observed in the southern end of the island, as both sides of the harbour are covered by sea walls and reclamations. Thus, coastal destabilisation is believed to be the major cause of erosion faced by the islands. Ukulhas and Bodufolhudhoo have undergone major coastal protection in 2017, involving reclamation and revetment parallel to reclaimed area. In Fuvahmulah, the harbour is constructed on the eastern tip of the island, minimising the disruption to longshore currents. However, the southern down drift side of harbour experiences accretion, while the northern side shows stronger impacts from waves. In Vilufushi, stability is more due to the huge shallow reef area minimising the disruption of longshore currents. On the other hand, Fuvahmulah has a very small distance between the reef edge and shoreline, making the island prone to various process regimes of waves and currents. Hence, Fuvahmulah faces the highest coastal destabilisation followed by Bodufolhudhoo. While Vilufushi is heavily fortified with a revetment, Ukulhas has a seawall protecting the down drift side of the harbour. Hanimaadhoo has capacity to accommodate for the destabilisation, due to steady equilibrium and natural stability. Consequently, the coastal process regime in all islands is destabilised. While Vilufushi and Ukulhas remain within acceptable thresholds, Fuvahmulah and Bodufolhudhoo are at the lower levels of tolerable thresholds. Hanimaadhoo is the only island showing natural stability and space for accommodation of impacts. However, given the level of vulnerability, Fuvahmulah, Bodufolhudhoo and Hanimaadhoo also require planned, hard engineered adaptations.

The five case study islands show distinct levels of sustainability regarding biogeophysical thresholds for adaptation to climatic stresses. While some islands have undergone more exogenous interventions, others require mobilisation of such interventions. Consequently, considering the biogeophysical barriers and limits, and the approaching thresholds owing to future climatic stresses, Bodufolhudhoo and Fuvahmulah are at the lowest levels of threshold, and Vilufushi is at the highest level. While Vilufushi has sustainable levels of biogeophysical limits due to exogenous interventions, Hanimaadhoo maintains a more natural steady dynamic state. Ukulhas has both exogenous and natural resilient features maintaining it within sustainable threshold levels.

6.8 Summary and conclusion

There is a dearth of literature on biogeophysical barriers and limits impacting the adaptive capacity of small islands. This chapter provided findings to fill these gaps by showing that biogeophysical barriers and limits are critical in the adaptive capacity of islands. This chapter identified the dynamic nature of barriers and limits, and how they may shift based on exogenous interventions. The findings provide further evidence that adaptive capacity is highly influenced by biogeophysical thresholds resulting from high vulnerability and exposure of islands to multiple hazards, coupled with anthropogenic factors, compromising firm limits of adaptation. Additionally, the findings from this chapter revealed that adaptation thresholds are shifted beyond the tolerable level, owing to biogeophysical limits.

The analysis from this chapter revealed that the two most significant biogeophysical limits faced are the lack of land and deterioration of the freshwater lens, based on the case study islands of the Maldives. Land scarcity lowers adaptive capacity, as the island lacks space for accommodation and retreat in response to climate stresses. For instance, no setbacks can be maintained, and loss of vegetation increases vulnerability, making any adaptation measures to reduce vulnerability extremely costly compared to their benefits. Additionally, deterioration of ground freshwater exacerbates vulnerability even more, as it has compounding effects on other biogeophysical barriers. The case of Bodufolhudhoo confirms these biogeophysical thresholds, lowering the adaptive capacity of the island.

These findings are critical as they demonstrate that biogeophysical limits, such as exposure to multiple climate stresses and vulnerability to climate stresses, is high in all islands. However, limits, such as scarcity of land, deterioration of fresh water, and coastal destabilisation, depend on the socio-ecological conditions on the islands. A major finding from this chapter is that the loss of land due to coastal erosion is complex and can seldom be attributed to climate change impacts alone. For instance, in all case study islands, coastal destabilisation, coupled with climate stresses and anthropogenic factors, results in very small net losses in land area. Additionally, the findings confirmed that anthropogenic interventions have major drawbacks in managing coastal dynamics in islands. For instance, on all islands, the construction of basin harbours has caused erosion in the downward drift area of harbours, or the proximity of harbours. Even though coastal revetments and elevating slopes of coasts reduce impacts, they compromise the space to accommodate for land gain by natural accretion. In terms of limits, the thresholds of freshwater lens and land availability have fallen below tolerable limits for Bodufolhudhoo. While Fuvahmulah is within acceptable threshold levels for these limits, the island faces the highest vulnerability to exposure of flooding and coastal erosion. Consequently, Fuvahmulah can adapt with exogenous hard engineered adaptations, while for Bodufolhudhoo, the costs of such measures may outweigh the benefits. Hence, the study has shown that, in terms of biogeophysical barriers and limits, Bodufolhudhoo has the lowest adaptive capacity, while Hanimaadhoo has the highest adaptive capacity.

Findings from this chapter also indicated the significance of designing and building hard engineered structures with proper measures for transformative adaptation. Additionally, despite enhancing the objective adaptive capacity of islands by overcoming barriers through hard engineering adaptations, such as reclamation and coastal protection, natural limits on certain aspects are further intensified. For instance, in Vilufushi, reclamation of land has reduced impacts of climatic stresses such as flooding, while soil conditions have become unsuitable for growing plants increasing the time span for natural succession and zonation of vegetation reestablishment on the island. Hence, the SIS needs to be revised to extend for natural stability, as islands like Hanimaadhoo may benefit more when provided with accommodation space for the island to remain within the natural dynamics of the process regime. However, on such islands, multifarious anthropogenic impacts, which may exacerbate firm biogeophysical barriers and limits, must be avoided through a proper balance of hard and soft adaptation measures and sustainable urban planning. These findings open avenues for further research on thresholds of biogeophysical limits on islands and to identify which islands have capacity to sustain human habitation for the predicted climatic stresses. Additionally, further research must be carried out on how hard and soft adaptation measures can be balanced to maintain the natural integrity of islands as much as possible. The next chapter will provide an indicator based adaptive capacity measure of islands.

CHAPTER 7: LOCAL ISLAND LEVEL ADAPTIVE CAPACITY BASED ON DETERMINANTS OF HOUSEHOLDS

7.1 Introduction

In the previous chapter, I discussed the biogeophysical barriers and limits of adaptive capacity. The previous three results chapters were based on contextual factors of the case study islands' socio-ecological systems, as well as climatic stressors impacting them. This chapter focuses on the contextual variables at the household level that influence adaptive capacity of communities on the islands. In this chapter, I will present the findings on household surveys from the case study islands, constructed from indicators based on the quantitative analytical framework presented in the methodology. This chapter will answer the following research questions:

1- *What are the specific determinants which influence adaptive capacity of communities on the islands of the Maldives?*
2- *What is the level of adaptive capacity level of the communities on the islands of the Maldives?*

To measure and assess the adaptive capacity at the household level, adaptive capacity was measured using a questionnaire survey. The approach was guided by the local adaptive capacity framework, integrated within the five capitals of the livelihood framework (Berkes et al., 2003; Chen et al., 2014; Cinner et al., 2018; Engle, 2011). The responses from the survey were obtained for 201 households from five islands, representing a total population of 12,081 local islanders. In the methodology chapter (Chapter three), I described the local adaptive capacity framework as the analytical framework for indicator analysis. This analysis provided an insight of the patterns and commonalities in adaptive capacity of island communities of the five case study islands. There are multiple indicators and analytical methods used in the assessment of adaptive capacity, as described in the literature review (Chapter two) of this thesis (Engle, 2011).

7.1.1 Adaptive capacity Indicators

The most widely used definition of adaptive capacity as given by the Intergovernmental Panel on Climate Change (2014b, p. 118), which stated adaptive capacity is "The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences". Due to the multidimensional spatial and temporal scales involved, adaptive capacity is influenced by multiple factors (Adger, Smith, Klein, & Huq, 2003). According to Adger et al. (2007), adaptive capacity is comprised of two dimensions, a generic and an impact-specific dimension. The generic dimension is more broad, with generic determinants, such as economic development, education, technology, knowledge, infrastructure, institutions, and social capital (Adger et al., 2007). Since the publication of the IPCC's fourth assessment, several methodologies have been used to assess generic adaptive capacity using indicator based analysis (Nhuan, Tue, Hue, Quy, & Lieu, 2016). The roots of most of these generic valuations lie in the Sen's capabilities theory and the sustainable livelihoods assessment (Mortreux & Barnett, 2017). Even though various methods and indicators are utilised in adaptive capacity assessments, most indicators are fitted within the five capitals of sustainable livelihoods, as natural, physical, financial, social, and human capital (Mortreux & Barnett, 2017). In their synthesis of adaptive capacity indicators, Cinner et al. (2018) identified five key domains to which adaptive capacity can be tailored in; they are assets, flexibility, social organisation, learning, and agency. Similarly, in the local adaptive capacity framework, the dimensions used are asset base, institutions and entitlements, knowledge and information, innovation and flexible decision making, and governance (Jacobs, Nelson, Kuruppu, & Leith, 2015; Nelson et al., 2010). In this study, we used 24 predictor variables to explore adaptive capacity of case study islands. Based on these dimensions, the indicators used will be outlined and examined below:

(i) Assets.

Assets are critical for adaptive capacity. For instance, the lack of tangible and intangible assets, and accessibility to resources, can limit ability of communities to cope with climatic stresses (Jones, 2011b). To understand the assets that are critical in an island context, we used housing condition, household wealth and assets, and the households' occupational characteristics. In terms of housing condition, we used proximity to shoreline as the most critical variable. Proximity to shoreline is important as households closer to shoreline are more vulnerable to climatic stresses resulting from storm surges and coastal erosion. Household wealth was based on socio-economic variables. We used durable assets, household's savings, number of flushing toilets, and number of water tanks as predictors of wealth. This is critical, as assets and wealth are crucial for coping with climatic stresses. In addition, we also examined the importance of external support through government aid, money, credits and loans and shelter. External support is imperative in climatic stress related discrete events, to manage, cope, and recover from climatic stresses.

(ii) Social organisation

Social institutions are critical to respond to a changing environment (Jones et al., 2010a). Social organisation encompasses the enabling mechanism for mutual support and cooperation, collective community action, and solidarity (Adger, 2010). We used variables to predict generosity, solidarity, cooperation, collective community action, and in-kind contribution by households in responding and coping with climatic stress. In addition, households also scaled importance of social bonding for their coping.

(iii) Learning

Learning relates to knowledge and information on climate change issues and effectiveness in utilising the information and knowledge (Cinner et al., 2018). For adaptive capacity, an understanding of future threats from climatic stress, the options available for coping, and how to strategize these options for coping are crucial (Jones et al., 2010a). We used indicators related to availability of information through sources such as mass media, and how knowledge influences the impacts experienced and in coping with these impacts.

(iv) Flexibility

Flexibility describes the diversity of options available to strategy adaptation and the ability to take advantage of opportunities (Cinner et al., 2018). Household human capital is crucial for their flexibility. We considered households with more adults above 18 years of age having higher secondary education, as well as more occupants outside the island for employment and education, to have more flexibility. Hence, indicators reflecting these aspects were utilised to assess flexibility.

(v) Agency

Agency describes the ways in which people can chose between different strategies in responding to climatic stresses and their ability to make choices (Cinner et al., 2018). We used indicators to assess households' ability to cope with past events, within the context of other resources to assess agency.

7.2 Method

In this research, we developed indicators based on the context of the small islands of the Maldives framed within the theory of islandness. The survey instrument contained 39 questions to explore adaptive capacity. We intended to obtain a minimum of 30 completed surveys from each of the five case study islands. However, a non-response bias was found after data cleaning for the islands of Bodufolhudhoo and Ukulhas, with only 21 and 29 completed survey forms, respectively. We rejected 38 surveys from the sample, due to non-response. Nevertheless, the statistical analyses concluded that the lower samples from both these islands had no impact on the validity and reliability of the results, as these two islands represented the smallest populations among our five case study islands. While Bodufolhudhoo has about 500 inhabitants, the population of Ukulhas was about 1000. In the development of the questionnaire, 24 variables within the socio-economic, institutional and socio-ecological dimension were empirically tested using the 39 questions. A pilot survey was carried out in one of the islands to validate the questionnaire, but was not included in the study.

Most indicator-based adaptive capacity assessments utilise Principal Component Analysis (PCA) for dimension reduction (Maldonado & Moreno-Sanchez, 2014; Nhuan et al., 2016; Selm, Hess, Peterson, Beck, & McHale, 2018). In the methodology chapter, I proposed an adaptive capacity index using multiple indicators with a value from 0-1 where closer to 1 indicates higher adaptive capacity. However, owing to the complexities in developing a composite indicator, due to limitations in standardising, weighting, and aggregating indicators, developing a single index of adaptive capacity was considered a major limitation (Maldonado & Moreno-Sanchez, 2014; Nardo et al., 2008). Hence, instead of deriving a single index, we explored the influence of various indicators on adaptive capacity, within the context of each island, and examined the variations among case study islands.

Linting and van der Kooij (2012) suggested that non-linear principal component analysis or the Categorical Principal Component Analysis (CATPCA) is ideal to obtain principal components of data sets lacking collinearity and having nominal, ordinal, and numeric measurement levels, as observed in our data. Hence, CATPCA was utilised in this study to obtain a smaller number of linear combinations, which represented the maximum variance within the variables (Linting & van der Kooij, 2012). CATPCA also overcomes the limitations posed by linear PCA in avoiding the assumptions of linearity of variables, and by allowing non-numerical variables to be incorporated (Linting & van der Kooij, 2012). For instance, ordinal variables from Likert scales can be easily incorporated in assessment. Hence, CATPCA was used for dimension reduction of the 24 variables related to adaptive capacity.

SPSS version 25 was used for the CATPCA analyses. As scree plots often do not indicate a distinct break, the dimensions were determined by numerical comparison of the variances accounted for, obtained from the SPSS output (Svedin, 2009). Since effect size (Variance Accounted For) has been suggested as the main criterion for variable inclusion (Linting 2012), we used to the total Variance Account For (VAF) to determine the most appropriate number of dimensions (i.e., "components" in Principal Component Analysis). Since a VAF of 50% is the benchmark for an excellent VAF (Comrey, 1973), we used VAF greater than 50% for variable inclusion. We utilised Varimax Kaiser Normalization to extract variables with eigenvalues greater than 1.0, as suggested by Svedin (2009), but in our sample, all eight dimensions had eigenvalues greater than 1.0. Items with rotated component loadings at or above 0.4 were chosen to be included in associated dimensions (Svedin, 2009). Cronbach's alpha was used as an indicator of consistency and reliability of estimates for indicators, and an alpha of at or above 0.8 was regarded as the acceptable value (Field, 2013). In choosing dimensions per island, we used VAF 50% as the benchmark. Hence, we only included dimensions for each island reaching a cumulative VAF of 50%.

7.3 Results

7.3.1 All islands combined

The total number of respondents sampled from five islands was 239, with 42 percent males and 58 percent females. The minimum age of respondents was 18 and the maximum was 85, with an average age of 45.8 years. The average numbers of years of schooling for household heads was 8.0 years. Even though 239 respondents took part in the surveys, 38 surveys were discarded, due to a bias of non-responsiveness in some critical questions. Hence, the total number of surveys used in final CATPCA was 201.

The CATPCA analysis provided a score based on component loading for each indicator representing the five dimensions. These scores indicated how strongly each indicator was associated with adaptive capacity. The CATPCA results for all islands combined showed eight components, with a total VAF of 58.08% with a very dominant first component. (VAF: Component 1= 10.7%, Component 2= 9.9%, Component 3= 8.6%, Component 4= 6.9%, Component 5= 6.2%, Component 6= 5.6%, Component 7= 5.2%, Component 8= 4.9%; Table 3.2.1). This shows that the eight components could account for 58 percent of variance in the 24 indicators of adaptive capacity. In this analysis the <0.40 criterion was used as the scale for significant indicator loadings as suggested by Svedin (2009). Table 3.2.2 displays the Rotated Component Loadings for all islands combined. Rotated component one contained variables related to household human capital, such as: percentage of people above 18 years of age; percentage of members above higher secondary level education; percentage of members migrated outside; and ratio of household members employed to total occupants. In addition, the living standard of the household, compared to rest of the community, was also loaded in this component. This component represented the contribution of household human capital for adaptive capacity. Rotated component two included all household assets, such as: durable assets; water tanks; and number of flushing toilets. Component three was mostly about ranking of external support for adaptive capacity, such as: money; government aid; and shelter. Component four was mainly a social capital related dimension indicating household members' participation in community activities and volunteering, as well as solidarity with other fellow islanders during events resulting from climatic stresses. Component five was about household economy and savings. Component six included ranking of support from community members and availability of finance through loans representing insurance mechanisms, and their influence on adaptive capacity. Component seven contained responses regarding how much the household relies on other members of community. Component eight contained responses on the importance of knowledge and information related to use of media sources, members representing NGOs, and experiences of consequences of climatic stresses.

19. Table 7.3.2.1 showing the model summary with eigen values and the variance accounted for each component for the 24 indicators.

Model Summary			
Component	Cronbach's Alpha	Variance accounted for	
		Total (Eigenvalue)	Percentage of variance
1	0.636	2.563	10.68
2	0.605	2.381	9.92
3	0.538	2.065	8.60
4	0.409	1.644	6.85
5	0.346	1.496	6.23
6	0.268	1.345	5.60
7	0.21	1.252	5.22
8	0.165	1.187	4.95
Total	0.969a	13.931	58.05
Total Cronbach's Alpha is based on the total Eigenvalue.			

20. Table 7.3.2.2 Varimax rotated solution of adaptive capacity indicators for all islands

Indicators assessed	Dimension							
	1	2	3	4	5	6	7	8
House distance from shoreline	0.033	0.035	0.192	0.122	0.269	0.398	-0.208	-0.033
Percentage of HH members above 18 years	0.476	-0.029	-0.008	0.044	0.282	0.260	-0.171	0.101
Percentage of HH members above secondary education	0.586	0.138	0.039	-0.156	0.042	-0.017	-0.005	0.223
Percentage of HH members migrated outside	0.715	-0.027	0.009	0.052	-0.068	-0.009	-0.033	-0.055
Ratio of employed HH members to total HH adults	0.540	-0.122	-0.117	0.059	0.580	0.015	0.085	-0.069
Job security of household head	0.119	0.124	0.243	0.138	-0.150	-0.595	-0.194	-0.174
HH savings	0.124	0.168	-0.053	0.049	0.687	-0.033	0.073	-0.071
Ranking of living standard	0.693	0.020	-0.059	-0.079	0.105	-0.050	0.116	-0.024
Number of water tanks	-0.064	0.688	-0.015	-0.007	-0.020	0.073	-0.189	0.155
Number of flushing toilets	0.105	0.802	0.080	-0.051	0.035	0.045	0.102	0.014
Durable assets	-0.014	0.700	0.111	-0.098	0.481	-0.054	-0.052	0.052
Participation in collective community action	-0.072	0.059	0.065	0.830	-0.083	-0.019	0.063	0.180
Perception on generosity of community	0.076	-0.073	0.139	0.206	0.009	0.102	0.770	0.016
Perception on solidarity and reciprocity of community	0.182	-0.027	0.067	0.659	-0.032	-0.090	0.388	-0.149
Ratio of HH members in NGOs to total HH adults	-0.004	-0.023	-0.142	0.220	0.140	0.154	-0.071	0.567
Voluntary in-kind contribution of HH in community activities	-0.251	-0.123	-0.032	0.538	0.226	-0.027	-0.082	0.091
Use of media sources	0.042	0.119	0.028	0.005	-0.149	-0.101	0.151	0.685
Experience of past impacts	0.354	0.081	0.112	-0.054	-0.072	0.007	-0.387	0.484
Ability to cope with past climatic stresses	0.059	0.389	-0.199	0.133	-0.326	-0.030	0.039	-0.117
Ranking of money in coping with impacts	0.237	-0.176	-0.636	0.025	-0.113	-0.278	-0.269	-0.133
Ranking of Government aid in coping with impacts	-0.127	0.011	-0.700	0.099	0.013	0.269	-0.223	-0.033
Ranking of credit and loans in coping with impacts	0.085	0.193	0.005	-0.125	-0.315	0.726	0.059	-0.068
Ranking of shelter in coping with impacts	-0.020	-0.039	0.832	0.223	-0.101	-0.010	-0.150	-0.187
Ranking of social organisation in coping with impacts	-0.205	0.040	0.335	-0.202	0.314	-0.427	0.482	0.281
Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 12 iterations. (Convergence = .000).								

As discussed in the methodology chapter (Chapter three), we incorporated the theory of islandness in the conceptual framework. As described previously, islanders build strong affiliations with their environment through mundane activities, and creative and skilful interactions with their community (Vannini & Taggart, 2013), which determines their adaptive capacity. Hence, we hypothesised that each island will be unique, even though a homogenous culture is seen in the Maldivian islands. In addition, the socio-economic characteristics and biogeophysical features of the islands studied demonstrated unique characteristics. Hence, understanding the dynamics of adaptive capacity of each island is imperative. Consequently, we applied CATPCA separately for each island.

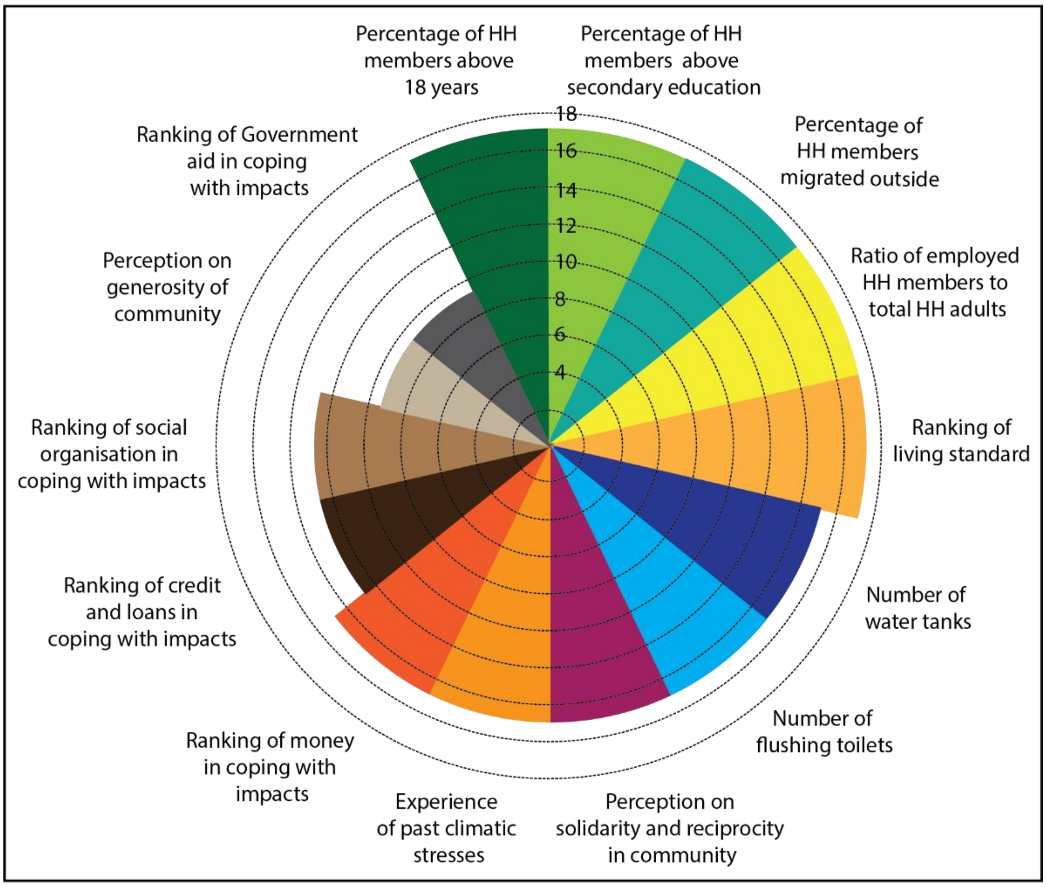
7.3.2 Analysis per island

7.3.2.1 Vilufushi

CATPCA results indicated that in Vilufushi, social organisation is very strong and influential. Similarly, adaptive capacity was higher in terms of the ability to recover from past impacts. They have also experienced much fewer significant impacts in the past, and have only a few household members affiliated with NGOs. The results showed that flexibility, in terms of human capital, was considered the most significant contributor for adaptive capacity. As shown in Figure 7.3.2.1, percentage of household members above 18 years, percentage of household members above secondary level education, and percentage of household members who have emigrated are observed as having highest cumulative VAF scores. Assets were ranked secondly and included rankings on living standards and ratio of household members employed compared to household adults, followed by number of water tanks and flushing toilets. However, assets related to external support were indicated as a lower contributor for adaptive capacity and there was a short fall of social organisation in terms of solidarity and reciprocity. Consequently, other social organisation related aspects, including generosity and ranking of social organisation, were considered lower contributors of adaptive capacity. Indicators showing negative values, will have considerable impact on adaptive capacity in their absence. These included solidarity and reciprocity of community, past experiences of climatic stresses, and external support through government aid and credit schemes.

21. Table 7.3.2.3 Model summary with eigenvalues and the variance accounted for each component for the 24 indicators for Vilufushi

Dimension	Cronbach's Alpha	Variance Accounted For	
		Total (Eigenvalue)	% of Variance
1	0.783	3.982	17.31%
2	0.741	3.429	14.91%
3	0.681	2.871	12.48%
4	0.562	2.164	9.41%
5	0.485	1.864	8.10%
6	0.419	1.668	7.25%
7	0.345	1.493	6.49%
8	0.174	1.200	5.22%
Total	0.989	18.673	81.19%
Total Cronbach's Alpha is based on the total Eigenvalue.			



35. Figure 7.3.2.1 Rotated solutions for 50 percent cumulative frequency of percentage of variance for Vilufushi

22. Table 7.3.2.4 Varimax rotated solution of adaptive capacity indicators for Vilufushi

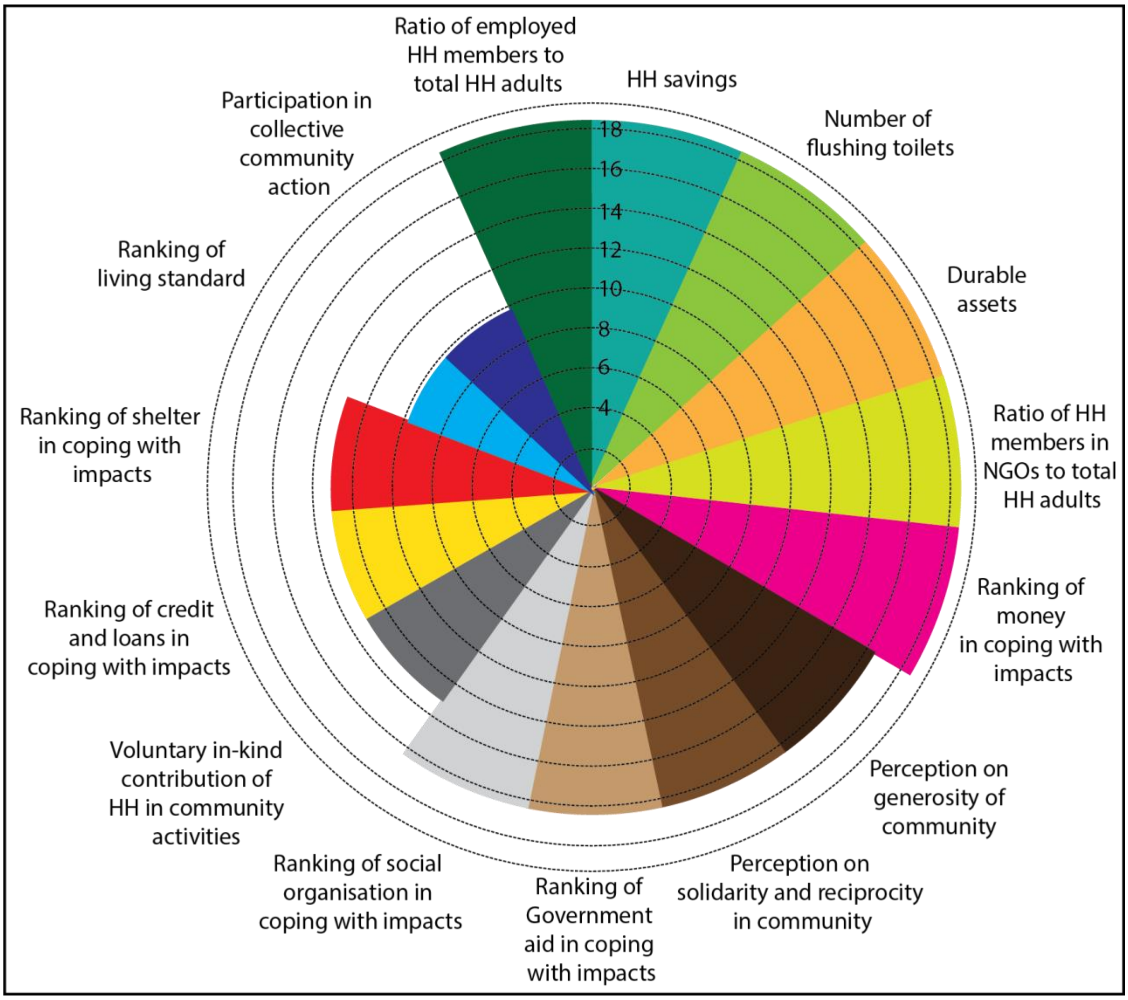
Indicators assessed	Dimension							
	1	2	3	4	5	6	7	8
Percentage of HH members above 18 years	0.692	0.006	0.304	-0.056	0.243	-0.062	0.245	-0.060
Percentage of HH members above secondary education	0.747	0.162	-0.164	-0.172	-0.012	0.074	0.042	-0.198
Percentage of HH members migrated outside	0.854	-0.008	-0.100	0.134	-0.014	-0.211	0.002	-0.114
Ratio of employed HH members to total HH adults	0.846	-0.198	0.043	0.003	-0.150	0.118	0.054	0.291
Job security of household head	0.017	0.108	-0.079	0.343	-0.213	0.002	-0.329	-0.711
HH savings	-0.037	-0.014	0.194	0.079	-0.211	0.024	-0.096	0.780
Ranking of living standard	0.757	-0.006	0.063	0.055	-0.254	0.327	-0.287	0.098
Number of water tanks	-0.065	0.795	0.531	0.185	-0.023	0.040	0.009	-0.023
Number of flushing toilets	0.050	0.890	0.384	0.065	0.107	-0.043	0.010	-0.089
Durable assets	0.084	-0.006	0.080	-0.097	0.794	-0.013	0.095	-0.129
Participation in collective community action	0.085	0.180	-0.070	0.020	0.141	0.030	0.838	0.152
Perception on generosity of community	0.096	0.026	-0.367	0.604	0.200	0.016	-0.083	0.425
Perception on solidarity and reciprocity in community	0.001	-0.886	0.152	0.027	0.029	-0.106	-0.035	-0.006
Ratio of HH members in NGOs to total HH adults	-0.132	0.143	0.178	-0.396	-0.405	-0.081	0.608	-0.181
Voluntary in-kind contribution of HH in community activities	-0.330	0.165	-0.005	0.104	0.745	0.088	-0.078	0.101
Use of media sources	-0.064	0.146	0.150	-0.249	-0.128	0.806	0.045	0.149
Experience of past climatic stresses	0.264	-0.425	0.085	0.211	-0.252	0.321	0.467	-0.347
Ability to cope with past climatic stresses	-0.118	-0.043	0.118	0.159	-0.203	-0.849	-0.002	0.117
Ranking of money in coping with impacts	-0.002	-0.744	0.110	-0.255	-0.112	-0.139	-0.396	0.042
Ranking of Government aid in coping with impacts	-0.135	-0.118	-0.074	-0.852	0.076	0.261	-0.028	0.086
Ranking of credit and loans in coping with impacts	-0.115	0.277	0.839	0.038	0.149	-0.067	0.190	0.143
Ranking of shelter in coping with impacts	-0.254	0.149	0.026	0.840	-0.036	-0.186	-0.026	-0.135
Ranking of social organisation in coping with impacts	-0.124	0.051	-0.923	0.096	0.047	-0.084	0.169	-0.125
Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 11 iterations. (Convergence = .000).								

7.3.2.2 Bodufolhudhoo

The highest contributor for adaptive capacity in Bodufolhudhoo was assets (Figure 7.3.2.2). The assets ranked as highest were ratio of employed household members to total household members, household savings, number of flushing toilets, and durable assets. The second highest contributor was social organisation, represented by generosity of community, and solidarity and reciprocity of the community. Assets of lower significance included external support through government aid, credits and finance, shelter, and living standards. Social organisation related indicators with significant contributions to adaptive capacity included ranking of social organisation, voluntary in-kind contribution of the household for community activities, and participation in collective community actions. No indicators representing learning, flexibility, and agency were observed with a VAF of 50 percent in Bodufolhudhoo Island. Indicators which may have significant impact in their absence were shown by the negative values and includes availability of external support through finance, credit schemes, and government aid.

23. Table 7.3.2.5 Model summary with eigenvalues and the variance accounted for each component for the 24 indicators for Bodufolhudhoo

Dimension	**Cronbach's Alpha**	**Variance Accounted For**	
		Total (Eigenvalue)	% of Variance
1	0.795	4.173	18.144
2	0.764	3.712	16.141
3	0.694	2.971	12.915
4	0.581	2.252	9.790
5	0.517	1.977	8.596
6	0.501	1.921	8.354
7	0.333	1.467	6.378
8	0.176	1.203	5.229
Total	0.992	19.676	85.548
Total Cronbach's Alpha is based on the total eigenvalue.			



36. Figure 7.3.2.2 Rotated solutions for 50 percent cumulative frequency of percentage of variance for Bodufolhudhoo

24. Table 7.3.2.6 Varimax rotated solution of adaptive capacity indicators for Bodufolhudhoo

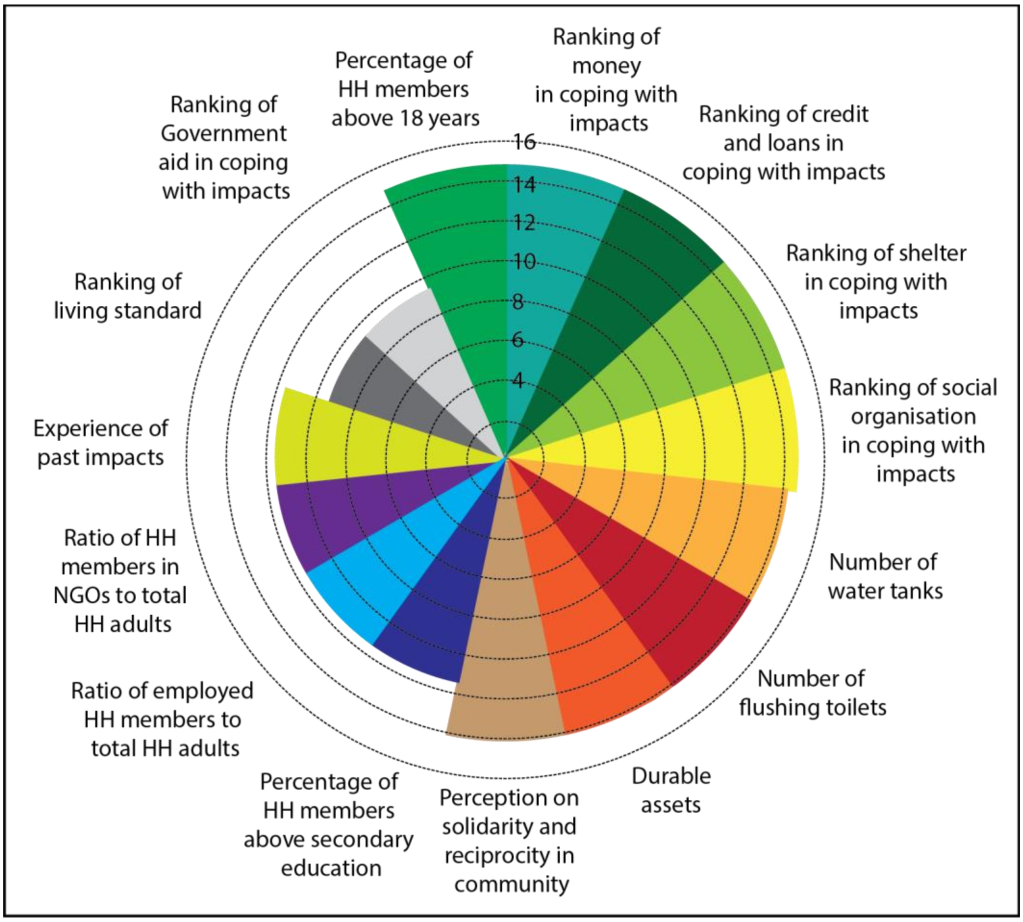
Indicators assessed	Dimension							
	1	2	3	4	5	6	7	8
House distance from shoreline	0.219	-0.088	0.247	0.397	0.114	-0.050	0.049	0.757
Percentage of HH members above 18 years	0.143	0.281	0.303	-0.217	-0.058	0.790	-0.130	0.233
Percentage of HH members above secondary education	0.005	-0.090	0.148	-0.174	0.123	0.237	-0.042	0.838
Percentage of HH members migrated outside	-0.031	-0.259	-0.199	0.075	0.023	0.889	0.021	0.036
Ratio of employed HH members to total HH adults	0.821	0.002	-0.053	0.150	-0.137	-0.128	-0.072	0.348
HH savings	0.637	0.516	0.084	-0.043	-0.201	0.172	0.405	-0.080
Ranking of living standard	0.098	-0.046	0.137	0.845	0.020	-0.104	0.042	0.145
Number of water tanks	0.162	-0.106	0.165	-0.041	0.116	-0.159	0.853	-0.111
Number of flushing toilets	0.673	-0.370	-0.129	0.020	0.382	0.231	0.008	0.033
Durable assets	0.809	-0.075	0.107	0.012	0.350	0.040	0.012	-0.012
Participation in collective community action	-0.090	0.094	0.303	0.775	0.102	-0.132	-0.345	-0.130
Perception on generosity of community	0.003	0.544	-0.139	0.53	0.335	0.066	-0.270	-0.198
Perception on solidarity and reciprocity in community	0.052	0.446	-0.204	0.761	-0.067	0.071	0.133	0.036
Ratio of HH members in NGOs to total HH adults	0.429	-0.332	0.025	0.582	-0.003	0.328	-0.243	-0.024
Voluntary in-kind contribution of HH in community activities	0.181	-0.077	0.941	0.117	-0.048	-0.078	0.006	0.120
Use of media sources	-0.225	0.241	-0.075	0.288	0.568	0.001	0.246	-0.173
Experience of past climatic stresses	0.273	0.034	0.071	-0.033	0.801	-0.182	0.108	0.129
Ability to cope with past climatic stresses	-0.088	0.040	-0.063	0.003	-0.828	-0.118	0.135	-0.147
Ranking of money in coping with impacts	-0.529	0.046	-0.044	-0.163	-0.073	0.127	0.702	0.191
Ranking of Government aid in coping with impacts	0.259	-0.933	0.012	-0.025	-0.116	-0.007	-0.020	0.046
Ranking of credit and loans in coping with impacts	-0.057	0.101	-0.961	-0.114	-0.004	0.067	0.010	-0.115
Ranking of shelter in coping with impacts	-0.304	-0.005	0.844	-0.070	0.168	0.185	0.206	0.109
Ranking of social organisation in coping with impacts	0.063	0.942	-0.140	0.106	-0.036	-0.136	-0.090	-0.065
Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 7 iterations. (Convergence = .000).								

7.3.2.3 Ukulhas

For Ukulhas Island, adaptive capacity was mostly influenced by social bonding, living standards, availability of loan aid, and participation in collective community action. Assets were ranked highest with some indicators related to flexibility and social organisation (Figure 7.3.2.3). However, indicators predicting assets were represented most significantly, and included external support mechanisms through finance and credit, shelter, and the number of water tanks, flushing toilets and durable assets. Social organisation was regarded as the next most significant contributor for adaptive capacity. Social organisation was demonstrated by indicators on ranking of social organisation, solidarity, and reciprocity of community and household members affiliated with NGOs. Flexibility was also a significant contributor to adaptive capacity, and was indicated by the percentage of household members above 18 years and percentage of household members above higher secondary education. The domain of learning was ranked as the fourth most significant contributor by the indicator representing learning from experience of past impacts. Other assets of lesser significance, but that were still crucial, were ratio of household members employed compared to household adults and living standard. Additionally, if solidarity and reciprocity of community, external financial support, and social organisation were absent, adaptive capacity could have a significant impact, and was represented with negative scores.

25. Table 7.3.2.7 Model summary with eigenvalues and the variance accounted for each component for the 24 indicators for Ukulhas

Dimension	**Cronbach's Alpha**	**Variance Accounted For**	
		Total (Eigenvalue)	% of Variance
1	0.750	3.561	14.8%
2	0.741	3.447	14.4%
3	0.665	2.760	11.5%
4	0.577	2.236	9.3%
5	0.521	1.998	8.3%
6	0.489	1.881	7.8%
7	0.325	1.452	6.1%
8	0.196	1.232	5.1%
Total	0.987	18.566	77.4%
Total Cronbach's Alpha is based on the total eigenvalue.			



37. Figure 7.3.2.3 Rotated solutions for 50 percent cumulative frequency of percentage of variance for Ukulhas

26. Table 7.3.2.8 Varimax rotated solution of adaptive capacity indicators for Ukulhas

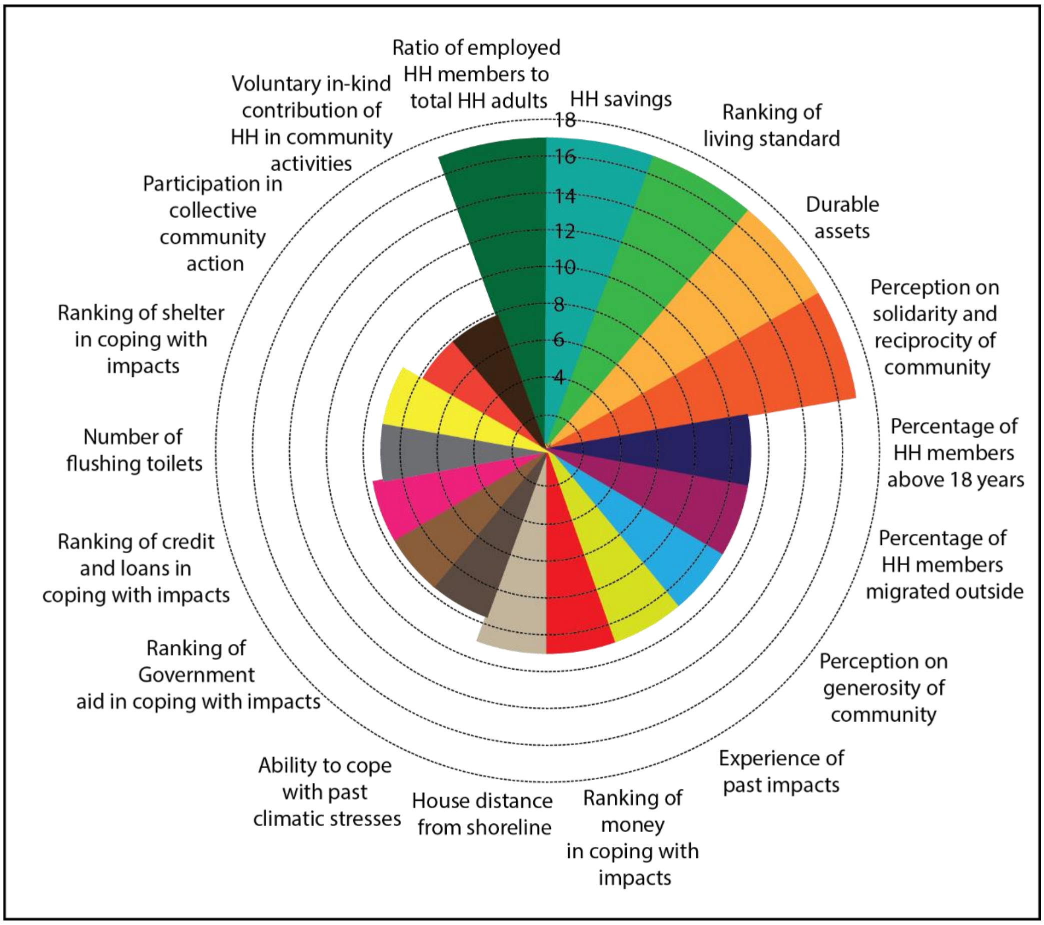
Indicators Assessed	Dimension							
	1	2	3	4	5	6	7	8
House distance from shoreline	0.333	0.268	-0.186	-0.001	0.795	-0.039	-0.145	0.015
Percentage of HH members above 18 years	0.406	0.211	0.440	0.203	-0.372	-0.377	0.103	0.106
Percentage of HH members above secondary education	-0.093	0.027	0.657	-0.081	-0.304	0.116	0.340	0.232
Percentage of HH members migrated outside	0.131	0.278	0.265	0.235	-0.571	0.340	0.052	-0.085
Ratio of employed HH members to total HH adults	0.057	0.160	0.470	0.095	-0.023	-0.680	-0.082	-0.260
Job security of household head	-0.310	-0.157	0.070	0.426	0.118	0.440	0.259	-0.214
HH savings	-0.317	-0.043	0.054	0.041	-0.137	-0.316	0.700	-0.081
Ranking of living standard	-0.122	-0.004	0.196	0.868	-0.088	0.017	-0.090	0.098
Number of water tanks	-0.202	0.776	-0.123	-0.160	0.015	0.187	0.073	0.008
Number of flushing toilets	0.066	0.848	-0.054	0.139	-0.111	0.000	0.001	-0.052
Durable assets	-0.084	0.793	0.110	0.152	0.129	-0.278	0.076	-0.068
Participation in collective community action	-0.187	-0.042	0.176	-0.044	0.873	0.205	-0.051	0.020
Perception on generosity of community	0.197	-0.125	0.017	0.138	0.116	-0.274	0.094	0.792
Perception on solidarity and reciprocity of community	0.157	-0.574	-0.169	0.383	-0.061	-0.134	0.083	0.534
Ratio of HH members in NGOs to total HH adults	-0.088	-0.064	0.762	0.078	-0.139	-0.310	0.110	-0.173
Voluntary in-kind contribution of HH in community activities	0.120	0.175	0.082	-0.141	-0.090	0.048	0.775	-0.061
Use of media sources	-0.187	0.011	0.121	-0.002	-0.028	0.273	-0.177	0.787
Experience of past impacts	0.166	-0.060	0.765	0.155	0.221	0.083	-0.042	0.147
Ability to cope with past climatic stresses	0.154	0.094	0.021	0.123	0.011	0.709	-0.250	-0.104
Ranking of money in coping with impacts	-0.487	0.188	0.177	0.562	-0.167	0.272	-0.303	0.066
Ranking of Government aid in coping with impacts	0.071	-0.390	0.364	-0.539	0.094	0.009	-0.309	-0.248
Ranking of credit and loans in coping with impacts	0.924	-0.072	-0.056	-0.214	-0.028	0.035	-0.033	0.023
Ranking of shelter in coping with impacts	0.484	-0.044	0.169	0.400	0.016	-0.082	0.617	0.186
Ranking of social organisation in coping with impacts	-0.928	0.146	-0.128	0.039	0.013	-0.101	0.002	0.026
Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 25 iterations. (Convergence = .012).								

7.3.2.4 Hanimaadhoo

Hanimaadhoo households perceived higher adaptive capacity in terms of households' savings, ratio of employed household members, reciprocity, and voluntary participation in community activities. For them, durable assets, living standard, and recent impacts experienced were lower contributors for adaptive capacity. In Hanimaadhoo, assets indicating percentage of household members employed, household savings, living standard, and durable assets were considered as highest contributors of adaptive capacity (Figure 7.3.2.4). The second most highly ranked contributor was flexibility, in terms of percentage of household members above 18 and percentage of household members above higher secondary education. Learning was ranked as next most significant and was indicated by past experiences of impacts. This was followed by agency, indicating ability to cope with past impacts. Social organisation, representing solidarity and reciprocity, was considered very significant, while voluntary in-kind contribution of the household in community activities and participation in collective community activities was also regarded with high significance. In Hanimaadhoo, indicators from all five domains were considered significant with different scales of significance. Indicators, which influence adaptive capacity in their absence, shown as negative values included generosity, solidarity, and reciprocity of community. Additionally, external support available through credit, financial aid, and shelter were negative, indicating that absence of these indicators will have a major impact on adaptive capacity of Hanimaadhoo island.

27. Table 7.3.2.9 Model summary with eigenvalues and the variance accounted for each component for the 24 indicators for Hanimaadhoo

Dimension	**Cronbach's Alpha**	**Variance Accounted For**	
		Total (Eigenvalue)	% of Variance
1	0.784	4.014	16.73%
2	0.649	2.644	11.02%
3	0.584	2.273	9.47%
4	0.557	2.146	8.94%
5	0.475	1.836	7.65%
6	0.407	1.640	6.83%
7	0.393	1.605	6.69%
8	0.228	1.280	5.33%
Total	0.984	17.438	72.66%
Total Cronbach's Alpha is based on the total Eigenvalue.			



38. Figure 7.3.2.4 Rotated solutions for 50 percent cumulative frequency of percentage of variance for Hanimaadhoo

28. Table 7.3.2.10 Varimax rotated solution of adaptive capacity indicators for Hanimaadhoo

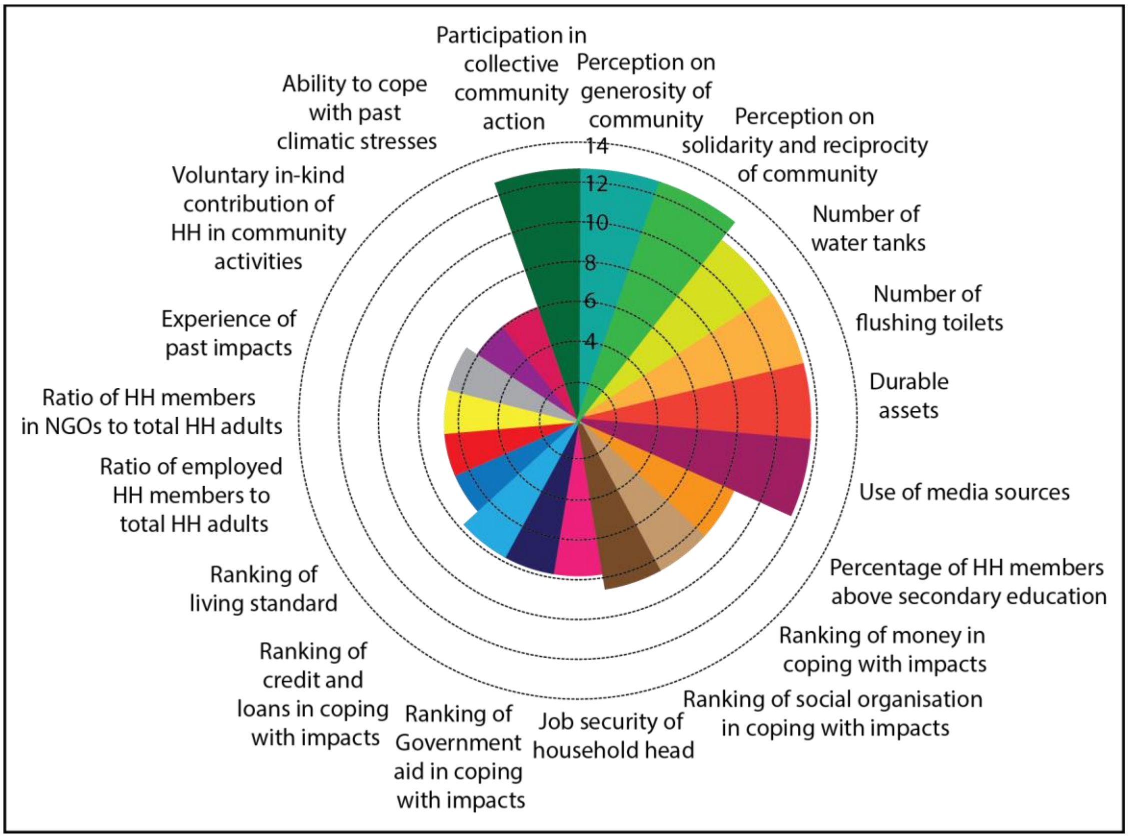
Indicators assessed	1	2	3	4	5	6	7	8
House distance from shoreline	0.016	0.036	-0.189	-0.152	-0.324	0.140	0.044	0.179
Percentage of HH members above 18 years	0.387	0.466	0.244	-0.159	-0.266	0.222	0.048	0.007
Percentage of HH members above secondary education	0.570	0.018	0.070	0.056	-0.465	-0.054	-0.253	-0.098
Percentage of HH members migrated outside	-0.023	0.726	0.129	0.394	0.040	-0.185	0.060	-0.158
Ratio of employed HH members to total HH adults	0.837	-0.024	-0.120	0.074	0.127	0.088	0.056	0.022
Job security of household head	0.051	-0.011	-0.117	-0.030	0.032	-0.713	0.060	-0.131
HH savings	0.930	-0.039	-0.145	0.011	-0.059	-0.014	-0.052	0.023
Ranking of living standard	0.547	0.078	-0.110	0.306	-0.111	0.260	0.206	-0.355
Number of water tanks	-0.085	-0.040	0.107	0.040	-0.080	0.207	0.066	0.822
Number of flushing toilets	0.236	0.013	0.190	0.645	-0.149	-0.305	0.085	0.294
Durable assets	0.609	-0.032	-0.101	0.208	-0.043	-0.173	-0.212	0.581
Participation in collective community action	-0.010	-0.194	0.262	-0.339	0.724	-0.052	0.310	-0.080
Perception on generosity of community	0.067	-0.801	-0.069	0.239	-0.049	0.100	-0.021	-0.050
Perception on solidarity and reciprocity of community	-0.424	-0.106	-0.008	-0.027	-0.020	0.231	0.827	-0.163
Ratio of HH members in NGOs to total HH adults	0.250	-0.319	0.124	0.071	0.311	0.624	0.093	-0.059
Voluntary in-kind contribution of HH in community activities	-0.032	0.146	0.019	0.045	0.853	0.163	-0.134	0.005
Use of media sources	-0.194	-0.203	0.140	-0.057	-0.040	0.274	-0.664	-0.209
Experience of past impacts	0.171	0.463	-0.057	-0.195	-0.228	0.456	0.142	0.279
Ability to cope with past climatic stresses	0.118	0.005	0.710	-0.159	0.082	0.203	0.392	-0.178
Ranking of money in coping with impacts	-0.059	0.533	-0.538	-0.141	0.094	0.353	-0.243	-0.224
Ranking of Government aid in coping with impacts	-0.319	0.161	0.744	0.043	0.155	0.131	-0.244	0.195
Ranking of credit and loans in coping with impacts	0.198	-0.124	-0.736	0.106	-0.120	-0.049	0.197	-0.048
Ranking of shelter in coping with impacts	-0.032	-0.048	0.265	-0.775	-0.211	-0.332	0.136	0.128
House distance from shoreline	0.104	-0.462	-0.102	0.748	-0.092	-0.022	0.059	0.070
Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 17 iterations. (Convergence = .000).								

7.3.2.5 Fuvahmulah

Fuvahmulah households believed the most influential factors in their adaptive capacity are social bonding, loan aid, recovery from past impacts, reciprocity, participation in community activities, and percentage of members that emigrated. Living standard was regarded as less influential, followed by job security, percentage of members above secondary education, and experience of past impacts. The results demonstrated that social organisation, predicted by variables indicating participation in collective community action, generosity of community, and solidarity and reciprocity of community, as the most significant in enhancing adaptive capacity (Figure7.3.2.5). These were followed by assets, indicating the number of flushing toilets, water tanks and durable assets in the household. The next most critical contributor enhancing adaptive capacity was percentage of household members above secondary education, indicating the domain of flexibility. Both learning and agency were ranked low among significant contributors and were represented by experience of past impacts and ability to cope with past impacts, respectively. Other significant indicators of assets included external support through finance and credits, job security of household head, government aid and living standard. Similarly, the social organisation domain related indicators, such as generosity, reciprocity, and voluntary in-kind contribution of the household was considered important. Fuvahmulah also demonstrated that indicators from all five domains enhance their adaptive capacity, but with differing significance levels. Those representing negative values, indicating an absence of these indicators, would have a considerable influence on their adaptive capacity, and were shown in indictors pertaining to external support, predicted through importance of availability of financial aid, credit schemes and shelter.

29. Table 7.3.2.11 Model summary with eigenvalues and the variance accounted for each component for the 24 indicators for Fuvahmulah

Dimension	Cronbach's Alpha	Variance Accounted For	
		Total (Eigenvalue)	% of Variance
1	0.699	3.028	12.62%
2	0.665	2.757	11.49%
3	0.535	2.052	8.55%
4	0.473	1.829	7.62%
5	0.379	1.571	6.55%
6	0.315	1.432	5.97%
7	0.252	1.318	5.49%
8	0.157	1.178	4.91%
Total	0.975a	15.164	63.18%
Total Cronbach's Alpha is based on the total Eigenvalue.			



39. Figure 7.3.2.5 Rotated solutions for 50 percent cumulative frequency of percentage of variance for Fuvahmulah

30. Table 7.3.2.12 Varimax rotated solution of adaptive capacity indicators for Fuvahmulah

Indicators	Dimension							
	1	2	3	4	5	6	7	8
House distance from shoreline	-0.088	0.264	-0.294	-0.113	-0.289	-0.034	0.004	0.621
Percentage of HH members above 18 years	0.057	0.093	-0.164	-0.018	0.136	-0.253	0.739	0.098
Percentage of HH members above secondary education	-0.032	0.035	0.482	0.091	0.127	0.440	0.375	0.169
Percentage of HH members migrated outside	0.034	-0.057	0.012	-0.019	0.033	0.061	0.813	0.061
Ratio of employed HH members to total HH adults	0.026	-0.242	0.094	-0.038	-0.039	0.175	0.256	0.639
Job security of household head	0.210	0.095	-0.006	0.532	-0.078	-0.108	0.154	-0.163
HH savings	0.097	0.089	0.121	0.102	0.148	-0.043	0.009	0.681
Ranking of living standard	0.131	0.302	0.289	-0.352	0.402	0.135	0.094	-0.143
Number of water tanks	-0.089	0.708	-0.161	0.028	0.338	-0.067	0.006	-0.040
Number of flushing toilets	0.194	0.745	0.247	-0.017	-0.137	0.230	-0.010	-0.044
Durable assets	0.000	0.783	0.186	-0.074	0.056	-0.040	0.030	0.118
Participation in collective community action	0.835	0.068	-0.016	0.126	0.150	-0.145	0.042	0.020
Perception on generosity of community	0.665	-0.039	0.223	-0.021	-0.423	0.029	0.053	-0.091
Perception on solidarity and reciprocity of community	0.856	0.076	-0.095	-0.058	-0.025	-0.030	0.009	0.126
Ratio of HH members in NGOs to total HH adults	-0.003	0.067	0.062	-0.006	0.734	0.049	-0.017	0.084
Voluntary in-kind contribution of HH in community activities	0.294	-0.164	0.184	0.073	0.290	-0.472	-0.118	0.320
Use of media sources	0.093	0.447	0.080	0.195	0.278	0.231	-0.020	0.001
Experience of past impacts	-0.082	0.144	-0.050	0.029	0.531	0.064	0.205	-0.070
Ability to cope with past climatic stresses	0.016	0.163	0.032	0.096	0.109	0.715	-0.159	0.092
Ranking of money in coping with impacts	-0.056	-0.211	-0.703	-0.182	0.241	0.241	0.154	-0.113
Ranking of Government aid in coping with impacts	-0.338	0.027	-0.212	0.631	0.167	0.375	-0.186	0.096
Ranking of credit and loans in coping with impacts	0.017	0.078	-0.176	-0.873	-0.058	-0.003	0.077	-0.103
Ranking of shelter in coping with impacts	0.267	0.124	0.238	0.396	-0.152	-0.603	0.015	0.025
Ranking of social organisation in coping with impacts	-0.023	0.118	0.845	-0.049	0.140	-0.006	-0.074	-0.015
Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 8 iterations. (Convergence = .000).								

7.4 Discussion

The CATPCA provided in depth knowledge of how various indicators are related to one another, providing guidance for further analysis. The comparison of islands from the CATPCA analysis indicated that different dimensions represented different indicators as principal components. The analysis for the 201 respondents from the five islands showed indicator-based assessment, demonstrating the usefulness of CATPCA in understanding the linearity of relations between diverse types of indicators. The sample represented 42 percent males and 58 percent females, with a mean age of 45.6 years, and mean education of 8 years. The analysis revealed that the 24 indicators rendered through CATPCA could be reduced to eight principal components and could describe more than 50 percent of the variance. The analysis revealed that most indicators used in this study had a high influence on adaptive capacity. The CATPCA delivered a score for each of the 24 variables of adaptive capacity, for each of the five case study islands. These scores determined the association of each variable with adaptive capacity. From the scores, I determined the contribution of each indicator for adaptive capacity of each case study island. As indicated in the previous sections, I categorised variables in to five key domains. These five domains and the indicators loaded into each of them will be described below:

(i) Assets

Assets represented the highest number of variables and included thirteen indicators. Contribution of assets for AC was very strong in most islands. However, assets were ranked highest by Bodufolhudhoo, followed by Ukulhas and Hanimaadhoo, respectively. Vilufushi showed the lowest ranking in terms of the importance of assets. Both Vilufushi and Fuvahmulah had lower contributions from assets compared to the others, but it was still considered a significant contributor. As Vilufushi Island was completely rebuilt and all homes were built to higher standard with better infrastructure and facilities, housing condition is not considered critical for them. However, they demonstrated external support as a major contributor for their adaptive capacity. Fuvahmulah, being a capital island and a city with more development, seemed to consider assets less significant. For Bodufolhudhoo, higher congestion, lower housing conditions, and assets were considered the highest contributors for adaptive capacity. Bodufolhudhoo also indicated external support as a critical contributor for adaptive capacity and included government aid, credit schemes, and financial incentives, as well as shelter. The results indicated that assets are most critical for smaller islands with a higher population density, lacking infrastructure and development. Housing condition seemed to be crucial, as Vilufushi, with improved housing, showed that they have more adaptive capacity.

(ii) Social Organisation

Six indicators were used to predict importance of social organisation for adaptive capacity on the islands. Social organisation was considered most critical by Fuvahmulah, followed by Bodufolhudho. In terms of mutual support and solidarity for adaptive capacity, Fuvahmulah was indicated as having the highest significance. For Bodufolhudhoo, social organisation was ranked second highest after assets. This result indicated that islands which are faced with multiple stressors, as indicated in other chapters, consider social organisation more critical for their adaptive capacity. For instance, Vilufushi indicated less significance for social organisation compared to other dimensions.

(iii) Learning

Learning was predicted based on two indicators, namely use of media sources and significance of past impacts for adaptive capacity. Experience of past impacts, as a significant contributor of adaptive capacity, was reported by all islands except Bodufolhudhoo. For Vilufushi and Hanimaadhoo, past impacts were considered higher than other islands. This could be due to association of the 2004 Indian Ocean Tsunami impact by Vilufushi islanders, and recent flooding experienced by Hanimaadhoo, respectively, and compared to other islands. In Bodufolhudhoo, discrete, severe events have not been experienced in the recent past, though the 2004 Indian Ocean tsunami had some impacts. In terms of use of media sources, only Fuvahmulah islanders indicated information from media is critical for their adaptive capacity. This could be due to vulnerability of the island to flooding, making them more conscious in utilising knowledge and information from the media. Additionally, they considered information from media sources to be more critical than experience of past impacts.

(iv) Flexibility

Flexibility was determined from four variables related to household human capital. Percentage of household members above 18 years, with higher secondary education and having more emigration compared to total members of households was regarded as having higher flexibility. Flexibility was considered to be the most critical by Vilufushi, followed by Hanimaadhoo and Ukulhas. Bodufolhudhoo showed the lowest level for flexibility, followed by Fuvahmulah.

Vilufushi had less employment available in the island, whereas Hanimaadhoo had more employment opportunities in the island. Hence, these two contrasts demonstrate that flexibility in terms of human capital is more significant for islands with occupational diversity. A smaller population in Bodufohudhoo, and being near to a resort, may have made human capital less significant, as they can easily find employment in the nearby resort. Fuvahmulah households considered percentage of members above 18 years to be important, but not as important as social organisation and assets.

(v) Agency

For agency, we used only one variable which predicted the ability of households to cope with past events. Except for in Fuvahmulah and Hanimaadhoo, the ability to recover from past impacts was not considered a significant contributor for adaptive capacity. This is most likely due to other islanders not having faced severe events, resulting in severe losses and damages, in the recent past. In Fuvahmulah and Hanimaadhoo, discrete events of flooding have been experienced recently.

7.5 Influence of Indicators on Adaptive capacity

The results demonstrated that indicators contributing to adaptive capacity in Maldivian islands are unique to the island's socio-ecological system. Even though all islands have a homogenous culture, there are unique differences in terms of biogeophysical and socio-economic conditions of the islands. Consequently, different islands demonstrated diverse levels of adaptive capacity within the five dimensions. All islands demonstrated assets, social organisation, and flexibility as critical contributors of adaptive capacity, while learning and agency was only significant for Fuvahmulah and Hanimaadhoo. Hence, both these islands showed a higher adaptive capacity in terms of all five dimensions of adaptive capacity. Furthermore, all islanders considered absence of external support mechanisms, such as government aid, finance, credit and loans, and shelter as having a noteworthy influence on their adaptive capacity. In addition, Hanimaadhoo, Ukulhas and Vilufushi also demonstrated that an absence of social organisation has a major effect on adaptive capacity. Consequently, assets, social organisation, and flexibility were deemed the most critical for adaptive capacity in Maldivian Islands.

In the islands of the Maldives, assets are critical as a means of strategizing and organising adaptation, both at individual and community level. For instance, during droughts, people depend on stored rain water and require assets like fans and air conditioners to respond to the increase in temperature. At a community level, people also require external support through government aid, finance, and credit schemes. For instance, during severe droughts, most islanders depend on water supplied from the government as disaster relief. However, external support through government aid and finance schemes are prone to power asymmetries and political dimensions (Cinner et al., 2018). For instance, adaptation related assets built by the government, such as harbours or reclamations, as electoral incentives, often undermine long term sustainability of coastal ecosystems (Sovacool, 2011). For example, in all case study islands, construction of the harbour has intensified coastal erosion, due to changes in natural coastal dynamics. Likewise, construction of sewerage infrastructure leads to pumping fresh water out in to the sea. This can cause nutrient overloading in some coastal marine areas, while also intensifying salinization of the freshwater lens. Household’s durable assets can also include items which can help them to respond better during emergencies. For instance, mobile phones, and other means of communication are vital. Housing conditions are also critical for adaptive capacity (Nhuan et al., 2016). Islanders now raise their homes and reinforce the structure with concrete and metals.

Social organisation in the islands of the Maldives is based on cooperation, and individual and community collective actions (Cinner et al., 2018; Marshall et al., 2009). Social organisation incudes community-based organisations, such as NGOs; in all islands, NGOs are present and active. While Bodufolhudhoo has only one NGO, Fuvahmulah has 25 NGOs. Both Hanimaadhoo and Ukulhas have two NGOs, while Vilufushi has three. Households in Fuvahmulah, Bodufolhudhoo and Ukulhas considered having household (HH) members in NGOs as a significant contributor of their adaptive capacity. Solidarity, trust, and cooperation, as well as in-kind contribution of households to collective community action, and taking part in collective community action, were given a high emphasis by all islanders. In the islands, people are heavily dependent on social organisation to compensate for the lack of physical resources. For example, many islanders mobilise their social bonding and linking to respond to climatic stresses and to recover and rebuild the community after such events. This is also reinforced through kinships and religious principles, as discussed in previous chapters.

The complexity of adapting to climatic stresses deems flexibility an essential tool for communities to enhance their adaptive capacity. Flexibility allows the utilisation of available opportunities in terms of resources and adaptation options (Cinner et al., 2018). Due to centralisation policies and lack of employment opportunities in the islands, human capital of households plays a crucial role in contributing to adaptive capacity. Households’ accessibility to utilise diverse financial resources is based on household members with higher education, and ability to migrate to work and earn. This acts as a financial coping instrument for households and the community.

The ability to utilise knowledge and understanding to strategize adaptive actions is critical. Hence, learning is a critical domain of adaptive capacity, allowing communities to utilise information and knowledge to mobilise and strategize adaptive actions, and to plan for the future (Adger, Arnell, & Tompkins, 2005; Folke & Berkes, 2000). Most islanders are aware of climate change impacts through mass media. We found that use of media was an important contributor for people of Fuvahmulah. Also, people utilise their experiences of past impacts as a means of preparing for future climatic stresses. For example, people use information from media as an early warning to prepare for climatic stresses.

The analysis from this result demonstrates how various indicators pertinent to assets, social organisation, flexibility, learning, and agency interplays in influencing adaptive capacity in the case study islands. This assessment implies that the interaction of indicators in influencing adaptive capacity of islands is distinctive and is based on the socio-ecological system of the islands. Even though they have similar socio-cultural aspects, they demonstrated the predictor variables of adaptive capacity are unique to the context of each island. Thus, the adaptive capacity of communities on Maldivian islands in responding to future climatic stresses is significantly influenced by assets, social organisation and flexibility. These dimensions act as effective contributors in mobilising adaptive capacity into actions allowing communities to cope and rebuild after climatic stresses. Nevertheless, their high dependence on external support, as shown by the present study, may pose challenges in coping for future. Therefore, building resilient island communities is critical to enhance adaptive capacity.

7.6 Summary and conclusion

As identified in the literature review, a gap in research on adaptive capacity assessment of islands is evident. This chapter intended to fill this gap by providing an assessment of adaptive capacity of island communities of the Maldives, based on a household level indicator assessment. The aim of this chapter was to identify the indicators that significantly contribute to adaptive capacity, as well as the strengths and limits of each case study island, in terms of mobilising adaptation through these indicators. The non-linear CATPCA method assessed 24 indicators pertinent to the five domains of adaptive capacity. Three domains were considered critical for all islands and included assets, social organisation, and flexibility. The islands, which indicated having more indicators contributing to their adaptive capacity, were regarded as having higher adaptive capacity. Generally, communities on bigger islands with lower population density and occupational diversity demonstrated higher adaptive capacity than those on smaller islands lacking resources. Households with more assets in terms of durable assets and good housing conditions, with more human and social capital, showed they have more flexibility and strength in terms enhancing their adaptive capacity.

This chapter demonstrated that indicator-based assessments using CATPCA is useful in adaptive capacity assessments. The major advantage of this method is that it can be used to compare the interaction of indicators, relative to the context of the case study islands. By using CATPCA, I minimised the limitations that could arise from normalising and aggregating indicators to a single index. While a single index can show a level of adaptive capacity, a composite index derived by aggregating multiple indicators may not provide robust results, due to the numeric and dynamic complexity in measurement of adaptive capacity. While such aggregations can summarise complex dimensions of adaptive capacity to a single index, it could also limit interpretation of how indicators contribute and influence adaptive capacity (Maldonado & Moreno-Sanchez, 2014; Nardo et al., 2008). Additionally, aggregating data into a single index requires weighting of indicators (Nardo et al., 2008). Multiple methods are available for weighting indicators, such as factor analysis and analytical hierarchy processes (Nardo et al., 2008). Such methods require extensive expert analysis and need to be validated through qualitative methods. Due to the limitations in time and resources available, we considered that CATPCA was a more convenient and a valid tool for adaptive capacity analysis in this study. Hence, the inferential ability of this method, and utility in overcoming limitations in aggregating, is considered significant for future studies on adaptive capacity of islands.

Several studies have identified the importance of the five domains of adaptive capacity analysed in this study and how it can be utilised to understand adaptive capacity at a local community level (Adger et al., 2003; Angell & Stokke, 2014; Below et al., 2012; Chen et al., 2014; Cinner et al., 2018; Goldman & Riosmena, 2013; Hinkel, 2011; Hogarth & Wójcik, 2016; Jones et al., 2010a; Nhuan et al., 2016; Wall & Marzall, 2006; Yohe & Tol, 2002). The findings from this chapter substantiate these notions, concluding that assets, social organisation, and flexibility are the most critical contributors of adaptive capacity for communities on Maldivian islands. Consequently, to enhance adaptive capacity in islands, the precarious economic conditions on islands must be addressed. In addition, resilience of island communities must be strengthened by increasing assets, such as physical resources and human capital. Additionally, social organisation on islands must be made robust by enhancing governance and leadership on islands so that the entire community can have equal opportunity to mobilise resources available for adaptation.

Findings from this chapter exemplify the numeric and dynamic complexity and contextual nature of adaptive capacity of the islands of the Maldives. This chapter contends that factors contributing to adaptive capacity are complex, making it essential to have a unique approach on different islands to enhance their capacity.

CHAPTER 8: CONCLUSION, FUTURE IMPLICATIONS AND CONTRIBUTION OF THESIS

8.1 Introduction

This chapter provides the conclusion of this study and discusses the implications for scholars, policy makers, and practitioners. The chapter begins with a summary of the findings based on the four results chapters, as stipulated in the research questions and objectives. This is followed by a final discussion on adaptive capacity of islands of the Maldives. The chapter will end with a personal reflection of the research process, based on contribution of research, and further research needs.

This thesis began by recognising the threat to SIDS, such as the Maldives, posed by global climate change impacts. The Maldives is a chain of atolls in the Indian Ocean, studded with small, low lying coral islands. The archipelago crosses the equator and expands over 800 kilometres in length and 150 kilometres in width. The socio-ecological system of the Maldivian islands demonstrates a precarious equilibrium of biogeophysical and socio-cultural features, highly vulnerable to global climate change impacts. According to recent findings, even if the GHG emissions are stabilised by the second half of this century, as pledged by the Paris Accord, a 2.6˚C warming will continue until 2100 (Tanaka & O'Neill, 2018), while also pushing the current trends in sea level rise to continue until 2300 (Mengel et al., 2018). Hence, low lying nations, like the Maldives, will face daunting challenges in adapting to future impacts resulting from such circumstances, making adaptation crucial for their survival.

Adaptive capacity is a critical concept linking vulnerability and resilience (Engle, 2011). The IPCC defines adaptive capacity as the "ability of a system to adjust, moderate and cope", by utilising the resources available (Adger et al., 2007 p. 869). It is widely agreed that adaptive capacity enhances the systems to manage climate change impacts efficiently, while also creating an enabling environment for transformative adaptation (Engle, 2011). The literature review of this thesis (Chapter two) reiterated that adaptive capacity of small islands is multi-dimensional in terms of spatial and temporal scales. Additionally, although adaptation has become critical for SIDS, like the Maldives, there is a dearth of studies on adaptive capacity and factors which influence adaptive capacity of small islands (Thomas & Benjamin, 2017). This has been identified as a major gap in this study and as the major motivation for conducting this research.

Studies on adaptation suggest lower adaptive capacity of islands due to their vulnerability and exposure, while some also indicate critical aspects of their resilience, as well as available opportunities owing to their dynamic socio-ecological system (Barnett, 2011; Birk, 2014; Church et al., 2006; Connell, 2013; Ford, 2012; Mann et al., 2016; Mimura et al., 2007; Nurse et al., 2014; Schwarz et al., 2011; Vinton, 2010). In addition, the literature review of this thesis demonstrated that, while research on adaptive capacity has gained momentum in the last decade, most studies are framed on assets based theories exploring influence of capitals and utilisation of resources (Freduah, Fidelman, & Smith, 2018; Mortreux & Barnett, 2017). Hence, these gaps in knowledge and the critical importance of adaptation for the Maldives prompted me to undertake this study, aiming to understand the potential for and limits to climate change adaptation capacity in the islands of the Maldives.

This research utilised a mixed methodology to understand adaptive capacity of small islands to climate change impacts. The study was developed based on a conceptual framework constructed to fit within the socio-ecological system of islands. The study was based on an analogue case study methodology to fulfil the research aims and objectives. The mixed methods study involved document analysis, PCCAA, interviews, and household surveys as the data collection methods. The study was designed based on the theory of islandness by integrating a resilient framework involving determinants related to sustainable livelihoods framework, as a guide for study data. This mixed methodology was successfully applied to five selected islands of the Maldives, as discussed in Chapter three of this thesis. This chapter summarises research findings and links the key findings from the research to the research questions. Accordingly, section 8.2 recalls the findings on the context of governance and institutions. Section 8.3 examines the influence of psycho-social dimensions and social discourse. Section 8.4 intensively evaluates the approaching thresholds of adaptive capacity related to biogeophysical barriers and limits on islands. Section 8.5 will examine the influence of determinants of adaptive capacity of island households. Section 8.6 will provide a conclusion on adaptive capacity of Maldivian islands, and section 8.7 extends to contribution of the research. Lastly, section 8.8 will provide future research possibilities.

8.2 Assessment of the determinants and endowments of governance and institutions in enhancing adaptive capacity.

The existing literature on adaptive capacity indicates that governance and institutions are critical for adaptive capacity, especially in marginalised communities (Bergsma, Gupta, & Jong, 2012; Eakin & Luers, 2006; Engle & Lemos, 2010; Sjöstedt & Povitkina, 2017). The political landscape and organisational structure are critical to mobilise adaptive action in terms of investments, leadership on stewardship of critical ecosystems which enhance adaptive capacity and in influencing policy through active participation of public (Sjöstedt & Povitkina, 2017). Additionally, government effectiveness and leadership are considered critical in reducing vulnerability of SIDS (Sjöstedt & Povitkina, 2017). The research investigated the determinants related to governance and institutional factors that influence adaptive capacity of islands. The empirical analysis of this chapter sets out to explore how variations in factors related to governance and institutions are inter-linked with adaptive capacity on islands. This chapter captured the potential for and limits in governance and institutional structures by exploring democratic characteristics of climate change policy formulation and implementation, and the bureaucratic nature of institutions on policy outcomes.

First, the governance of environment was observed to be centrally institutionalised with a cabinet level Ministry, mandated to formulate climate change policies and to deliver policies through various strategies and programs at national and local levels. At local levels, Island Councils, or City Councils are the formal institutions mandated to assist the central government Ministry, in implementing policies. Informal institutions include social networks, and local and national level NGOs. Policy actors identified included those with vested interests in policies, such as corporate elitists and environmental NGOs, as well as the public, including local islanders. Policy outcomes were inefficient and often against people's perceptions of actions enhancing their adaptive capacity. For instance, streamlined focus on economic development is found to be undermining stewardship of ecosystems enhancing adaptive capacity. Examples of this include trade-offs between environment and development, disregarding protecting coastal marine systems, such as reefs and mangroves on the behest of land reclamation and other coastal modifications.

This research contends that climate change policy in the Maldives has been defective due to the legacy of authoritative environmentalism and path dependent historic institutionalism.

Adaptive capacity is also found to be influenced by collective community actions and informal institutions on islands, owing to deficiencies in political institutions in terms of resources and governance. The research also concluded that while governance at local island levels, through formal institutions, have no variations among islands, leadership from the local Island or City Councils is crucial. For instance, it was found that the council's ability to collaborate and cooperate with informal institutions in responding to discrete climatic stresses, such as flooding due to rain, enhances adaptive capacity of communities. Hence, informal institutions make a substantial contribution to adaptive capacity.

The findings indicate that the highest political level of the Maldivian government is heavily involved in climate change related issues at a global level, while lacking emphasis on mobilising strategies for adaptive capacity at national and local island levels. In addition, like many other SIDS, the Maldives is also faced with a lack of representation of vulnerable and marginalised island communities, lack of knowledge and accessibility, high corruption, lack of effective compliance and enforcement mechanisms, and inadequacies in ruling by rule of law. Similarly, the legacy of authoritative environmentalism has favoured policies against the wider scientific views on the complexities and uncertainties of climate change, leading to distortion of scientific uncertainties to facilitate "rent seeking" policy of the governments. This study concludes that, for the Maldives to implement climate change policy effectively, policy processes, programs, and political decisions need to adopt democratic environmentalism by diffusion of authority over all policy actors and wider stakeholder consultation (Gilley, 2012). Additionally, the policy outputs should ensure that social, civil, and political liberties of the people are ensured by making governance more democratic and transparent at national and local levels.

8.3 Role of social discourse and socio cognitive factors in climate change adaptive capacity

This research was founded on the notion that adaptive capacity and adaptation outcomes can only be manifested through belief efficacy of local islanders. Based on this principle, the Model of Private Proactive Adaptation to Climate Change (Grothmann & Patt, 2005b) was examined using theory of islandness. Islanders' perceptions of climate change influences how they adapt and make decisions and is linked to risk perception, social norms, and perceived efficacy of their adaptive strategies and responses (Wang, Leviston, Hurlstone, Lawrence, & I. Walker, 2018). One of the pressing issues, identified from the literature review of this study, was the lack of research on SIDS like the Maldives, in the environmental psychological climate change literature (Thomas & Baptiste, 2017). However, to understand adaptive capacity at an island level, the linkages of socio-cognition and factors motivating people to undertake adaptation were considered crucial (R.A. Smith, 2018).

This chapter explored socio-cognitive aspects of island communities on climate change impacts and how islanders' motivations for adaptation enhance their adaptive capacity. In view of the theory of islandness (Vannini & Taggart, 2013) and cultural theory of risks (Douglas, 1994), psycho social dimensions of adaptive capacity in island communities is regarded as a construct of perceived risks and perceived capacity to cope and adapt. These perceptions are garnered through lived experiences of people, their cultural values, beliefs and experiences in the context of their interaction with the socio-ecological environment of the islands (Etkin & Ho, 2007). Furthermore, these theories also accommodate the cultural imagery of islanders enduring and living with the dynamics of climatic stresses by shifting their ways of life in a dialectical interplay in social and ecological processes (Ingold, 2000; Vannini et al., 2012; Vedwan, 2006).

Consequently, individual and community level perceptions of risks and experiences are considered critical for adaptive actions and behaviours (Adger et al., 2009) and, therefore, adaptive capacity of islands. The major conclusions from this assessment are:

1. Perceptions on severity and probability of climatic stresses are based on direct experiences and were of considerable significance, influencing intuition, emotion, and motivation of islanders.

2. Climatic stresses of significance included increase in temperature and flooding due to rain, and were based on direct experiences of consequences of these impacts.

3. Association of sovereignty of God with risk imagery and elevated expectations of government aid results in fatalism and wishful thinking, respectively.

4. Judgements regarding subjective adaptive capacity were significantly higher in all islands except in Vilufushi.

5. Reactive event driven adaptation responses were a major *in situ* coping strategy, while lacking transformative adaptation.

6. Islanders have high intentions and motivation for adaptation, driven by high efficacy of risk appraisal and adaptation appraisal.

7. Islanders demonstrated a higher psychological resilience, even though it may not enhance their transformative adaptive capacity.

This chapter highlighted that, even though accuracy and scientific knowledge of climate change impacts was lacking in island communities, the islandness and direct experiences in climatic stresses, as well as social construction, lead to an elevated risk appraisal. Meanwhile, social representations and social processes had a lesser influence on risk efficacy. Similarly, the findings confirmed that people have a higher perceived self-efficacy and perceived costs of adaptation. The findings confirm that social capital is central in enhancing objective capacity, while subjective capacity, based on social construction and social representation, is lowered by inflated costs, fatalism, and wishful thinking.

8.4 Synergies and trade-offs and approaching barriers and limits on the adaptive capacity thresholds

Although literature on climate change assessments has a major focus on drivers of climate change, a gap regarding significance of thresholds, feedback loops, and their temporal dynamics is evident (Lenton et al., 2008). A threshold is defined as a point at which the system shifts from one state to another (Walker & Meyers, 2004). Findings from (Werners et al., 2013) identified that, to examine thresholds, the scale at which the threshold is crossed from reversible to intractable levels, the positive feedback loops and their onset, and the influence contributed by climate change or other endogenous and exogenous drivers of the system, must be explored. The biogeophysical variables, such as coastal geomorphology, island vegetation, and island freshwater lens are heavily influenced by climate defined variables, such as changes in sea level, rain fall and temperature, as well as anthropogenic drivers arising from population pressure, urbanisation, and vegetation clearance. Dynamic interaction of these variables results in a spatial feedback within the adaptation space of islands, and either reduces or amplifies the adaptive capacity thresholds through different spatial and temporal feedback loops (Cumming, 2011). These variables act synergistically as positive feedbacks push the island towards adaptation thresholds and tipping points (Cumming, 2011). For instance, coastal destabilisation, freshwater lens degradation, and loss of critical ecosystems are some system variables that can cross adaptive capacity thresholds due to the non-linearities in their response to changes in climate change defined variables (Cumming, 2011). However, many such thresholds are also dynamic, even though they may exceed intractable levels, thereby immobilising adaptive capacity (McNamara et al., 2012).

A dynamic stability in adaptive capacity thresholds exists on islands due to the interconnectedness of climatic stressors with biogeophysical conditions (Morrison & Pickering, 2013), as well as the subjective and endogenous nature of feedbacks and tipping points (Adger et al., 2009). For instance, a study on barriers and limits to adaptation in nineteen SIDS revealed that, physical and ecological variables accounted for 28 percent of adaptation thresholds faced by them (Robinson, 2018). Consequently, this study recognised the barriers and limits, and response of biogeophysical variables, on adaptive capacity thresholds of islands. This chapter examined biogeophysical variables and how they have been responding to climatic and other anthropogenic impacts over the past. The adaptive capacity thresholds were based on morphology, land use, and environmental degradation.

About 1,000 years ago, Maldivian islands maintained alternate stable states with the changes in biogeophysical variables, such as coastal erosion through their natural buffering capacity, via negative feedback loops maintaining a negative entropy. Islands in such a state can be said to have an intricate and precarious balance of system variables, easily shifted by amplifying feedbacks. Consequently, due to the high vulnerability and exposure from climatic stresses in the recent past, the biogeophysical variables began demonstrating non-linearity in their response to changes in climate change defined variables, such as sea level rise resulting in positive entropy. This non-linearity response is also partly intensified by other anthropogenic pressures. Subsequently, in many instances, the adaptive capacity thresholds of the islands were crossed to intractable limits. This prompted exogenous, engineered adaptations to enhance adaptive capacity, thereby inhibiting the effect of climate change impacts, while limiting self-repairing and self-maintaining capacity of islands.

Findings from this chapter indicated the adaptive capacity thresholds are approaching in all islands except in Vilufushi, where exogenous interventions have reduced crossing of the threshold to intractable limits. Findings also showed that islands with limited space, a smaller freshwater lens, and intensified anthropogenic pressures, are rapidly approaching their adaptive capacity thresholds compared to others. For instance, in the island of Bodufolhudhoo, the freshwater lens and adaptation space have now crossed the adaptive capacity thresholds to intractable levels and requires immediate engineered solutions. However, the island of Hanimaadhoo remains stable through negative feedbacks and available adaptation space, reducing the effect of climate change impacts. Yet, the existing data and models indicate that climate change impacts will continue intensifying. For instance, Storlazzi et al. (2018) demonstrated that non-linearities in the response of island biogeophysical variables to changes in sea level rise, wave over topping, and the resulting flooding of islands, causes crossing of adaptive capacity thresholds to intractable limits rapidly. They concluded that if current climate change trends continue, atoll islands may not be able to support human habitation by the mid-21st century. The analysis from this chapter revealed that the two most significant biogeophysical limits faced are a lack of land and deterioration of the freshwater lens. Land scarcity lowers adaptive capacity, as the islands lack adaptation space to accommodate and retreat from climatic stresses. For instance, no coastal setbacks can be maintained, while loss of vegetation increases coastal destabilisation, making any adaptation measures to reduce vulnerability extremely costly compared to their benefits.

8.5 Determinants of household adaptive capacity

Adaptive capacity, measured at a macro scale may not indicate household scale, imperative to understanding adaptive capacity at a local level (Toole et al., 2015). Meanwhile, macro level changes in adaptive capacity are displayed as dynamic, local conditions through household socio-cultural and socio-economic features (Williams et al., 2016). Hence, household adaptive capacity has gained increased attention, especially in developing countries (Toole et al., 2015), and was considered essential for this study. In this study, we explored the contextual variables, at the household level, which influence adaptive capacity of islands. The analysis was carried out by an indicator-based methodology framed by integrating local adaptive capacity framework with sustainable livelihoods framework. The indicators analysed were synthesised into five domains; assets, social organisation, flexibility, learning, and agency

Findings from this chapter indicated that, on all islands, assets, social organisation, and flexibility are the most crucial contributors of adaptive capacity. Assets were ranked as the highest contributors by Bodufollhudhoo and Ukulhas. Assets were considered least significant by Fuvahmulah, followed by Villufushi. Social organisation was regarded as the most significant contributor for adaptive capacity by Fuvahmulah, followed by Bodufolhudhoo. Vilufushi households considered flexibility as the most crucial contributor of adaptive capacity, followed by Hanimaadhoo. For Bodufolhudhoo, flexibility was of least significance, followed by Fuvahmulah. Vilufusi and Hanimaadhoo emphasised that learning was a crucial contributor to adaptive capacity, while it was not considered significant in Bodufolhudhoo. Also, Fuvahmulah and Hanimaadhoo were the only islands which regarded agency as a major contributor for adaptive capacity. Hence, regarding all five domains, both Fuvahmulah and Hanimaadhoo showed higher adaptive capacity, as they regarded all five domains as contributors to their adaptive capacity. Bodufolhudhoo showed the least, as contributors of their adaptive capacity lacked learning and agency. This was followed by households of Ukulhas. Vilufushi showed a middle level in adaptive capacity compared to the rest. Hence, at a household scale Fuvahmulah and Hanimaadhoo had higher adaptive capacity, while Bodufolhudhoo had the least, followed by Ukulhas.

8.6 Final conclusions on adaptive capacity

This research examined adaptive capacity of the islands of the Maldives at a local socio-ecological scale, from macro to micro levels. At a macro level, the role of governance and institutions was explored before moving to a meso level, at the island scale, community scale and household scale.

In conclusion, the findings answered the major questions that formed the objectives of this research:

1. What socio-economic, biophysical, and governance related variables influence the adaptive capacity on Maldivian islands?
    - The findings indicated that assets are critical for adaptive capacity at a household level.
    - Housing conditions, household infrastructure, and household wealth, such as durable assets and savings, are critical contributors of adaptive capacity.
    - Additionally, external support through government aid, money, credits and loans, and shelter are also critical.
    - Biophysical variables critical for islands are land availability for adaptation and quality of the freshwater lens of the island.
    - Governance variables have a critical influence, including political institutions, such as effective governance and democracy, as well as informal institutions.
2. Which determinants have the greatest influence on the adaptive capacity thresholds?
    - Adaptive capacity thresholds are crossed to intractable levels by biogeophysical aspects related to environmental degradation, such as coastal destabilisation and salinization of freshwater lens, as well as loss of vegetation.
    - Other determinants accelerating the crossing of thresholds include changes in climate defined variables, such as temperature and rainfall patterns.
3. What barriers and limits are approaching adaptive capacity threshold?
    - Biogeophysical barriers and limits are most critically approaching adaptive capacity thresholds.

- Also, efficacy beliefs related to sovereignty of God and wishful thinking, regarding government aid and support, are major barriers and limits.

4. Do the islands of the Maldives have adaptive capacity to cope with future threats of climate change?

- Islands do not have inherent adaptive capacity.
- Islands are at their tipping points.
- Any amplifying feedbacks defined by climate change impacts can rapidly cross the adaptive capacity thresholds to intractable limits.
- While some islands can reduce these effects, smaller islands, lacking adaptation space and those faced with salinization of freshwater lens, require immediate exogenous interventions.
- Well planned, transformative adaptation, mainstreamed with exogenous interventions, can buffer changes in climate defined variables.

8.7 Evaluation of research contribution

This research fills a gap on adaptive capacity of small islands by using an island centric methodology. The research has contributed substantially to ideas and origins of adaptive capacity on islands at an epistemological, socio-ecological, and socio-cognitive level.

8.7.1 Theoretical and methodological implications

In encoding and decoding adaptive capacity from an island epistemology, this research utilised an island centric methodology, based on island ways of knowing, doing, and being. The research employed the theory of islandness, as epistemology is determined by culture and context, allowing encoding ad recoding of the social reality of the phenomena of climate change adaptation on islands (Vannini & Taggart, 2013). The conceptual framework developed was outlined to incorporate the adaptive capacity of island socio-ecological system. A mixed methods approach made it possible to obtain empirical evidence of adaptive capacity by transcending the analysis from theory of islandness to island specific case studies. This type of systematic methodology is crucial for researchers to examine adaptive capacity through temporal or spatial analogue case studies. One of the most critical contributions of this thesis was the mixed methodology, resulting in research outputs of distinct inferences each contributing to the understanding of adaptive capacity of islands. PCCAA outputs identified governance and institutional aspects influencing the adaptive capacity of islands. In addition, PCCAA also generated outputs on biogeophysical barriers and limits, and was incorporated with GIS to further delineate adaptive capacity thresholds on islands. The interview results provided major evidence on socio-cognitive and belief efficacy on adaptive capacity, as well as how adaptive capacity is translated into actions on the ground. The surveys provided a quantitative measure of contribution of different indicators for adaptive capacity. Document analysis provided outputs for qualitative analysis on aspects of institutions and governance on adaptive capacity. Consequently, the mixed methodology has provided us with: (a) critical determinants of adaptive capacity for islands; (b) how these determinants interact within the socio-ecological system of islands; (c) how these determinants causes barriers and limits for adaptive capacity; and (d) how adaptive capacity is enhanced or maintained in islands and existing capacity of islands.

Findings from this thesis suggests that islands are dynamic in terms of biogeophysical and socio-cultural aspects. Hence, in order to understand climate risks and resilience of Maldivian islands, the inter play of politics, donor funding, hard engineering and local community aspirations in implementing adaptation has been interpreted from the results. As found by Yarina and Takemoto (2017), the interplay of these factors poses major challenges in Tuvalu, in implementing adaptation measures to address coastal erosion. Islands are dynamic and constantly evolve and grow to compensate changes in sea level, albeit being hindered by ocean acidification and coral bleaching due to climate change (Yarina & Takemoto, 2017). Consequently, the living geography of islands maintains a negative entropy within the coastal regime to remain in a stable state. When the intricate balance of entropy is lost due to anthropogenic hard fixes and sedentarisation, positive entropy kicks in, resulting in a huge cost burden to sustain the stability of coastal geomorphology of islands. This thesis argues that the biogeophysical thresholds of islands must be maintained by allowing the negative entropy of the system to thrive. This will result in an adaptive capacity surplus and enhance resilience. Consequently, the government must plan and implement adaptation measures to respond to coastal erosion by accommodating the living geography of Maldivian islands.

8.7.2 Policy implications

Findings from Chapter four have major policy implications, as governance and institutions are critical for adaptive capacity in islands. Hence, in formulating policies, the political context needs to be equally emphasised, along with technical aspects of climate change impacts

(Sjöstedt & Povitkina, 2017). This research identified policy gaps in climate change governance in the Maldives, both at national and local island levels. The critical insights gained from this research is important for decision making, as understanding adaptive capacity of islands is crucial for developing policies, programs and strategies. The outputs confirmed that *ad hoc* trade-offs between environment and development are a major impediment for adaptation on islands. For instance, during the past five years, Maldivian government embarked on massive construction projects largely financed by Chinese credits and loans. In addition, reclamation of shallow reefs and lagoons was favoured, enhancing climate risks and lowering resilience of Maldivian islands. For an example, document analysis of environmental impact assessment reports of major projects undertaken lacks emphasis on future climate change risks to transport infrastructure such as roads and airports. Meanwhile, increase in greenhouse gas emissions from such projects have been undermined. Consequently, land reclamation projects must allow for adaptation space and set-backs, while major infrastructure should be built to mitigate climate risks.

In addition to environmental impairments caused by major developments, event driven adaptations often result in maladaptation while preventing transformative adaptation. Hence, mainstreaming transformative adaptation in major development projects on islands is critical for the Maldives. Similarly, current policies on population consolidation and safer islands strategy need to be reviewed. The findings also indicate the importance of effective governance at local levels, and the importance of democracy and transparency in enhancing adaptive capacity of islanders. Additionally, efficacy beliefs of islanders need to be understood by policy makers, for effective communication and empowerment of islanders.

8.8 Limitations and directions for future

Although this study provides a benchmark baseline of adaptive capacity of islands of the Maldives, there are certain limitations, providing scope for future research. Through an island centric epistemology and a mixed method approach, this study has shown that adaptive capacity on islands is complex and multi-dimensional, with distinct temporal and spatial scales. While theory of islandness, from a nonrepresentational dwellings perspective, has emerged recently (Vannini & Taggart, 2013), scholars have raised questions whether "a coherent theory of islandness is possible?" (Hay, 2006, p. 19). Hence, a theoretical approach based on theory of islandness may require further deliberation. While this research utilised an analogue case study approach, exploring an ethnographic phenomenological approach in future research could be of interest.

While the mixed methods approach used in this study made it possible to explore complexities and multi-dimensionalities of adaptive capacity through a broad range of research questions, the approach poses some limitations. As found by (Johnson et al., 2007), mixed methods are more challenging, due to demand for multiple methods in analysis and challenges in mixing them to obtain one research objective. Consequently, this study resulted in extensive field work and analysis of data using both qualitative and quantitative methods. Additionally, strong meta-inferences, from both qualitative and quantitative analyses, had to be derived making it a major challenge. Hence, future research on adaptive capacity may need to explore a pure qualitative or quantitative paradigm, if time and resources are a constraint.

Multiple dimensions of adaptive capacity were explored in this study, based on a wide range of indicators related to environment, socio-culture, socio-economics, and governance. However, redundancy of indicators was inevitable and was a major limitation, due to the interlinkages of indicators. Additionally, subjectivity of research participants is unavoidable, as participants' responses are heavily influenced by their knowledge, perceptions, and attitudes regarding climate change. Hence, future research should focus on more robust sampling techniques, such as snowballing or other criterion sampling strategies. A major outcome of this thesis is that Maldivian islanders are resilient and have higher subjective adaptive capacity. Further research should explore implications of this resulting in climate refugees in the Maldives.

8.9 Concluding remarks

Research interest on adaptive capacity has gained momentum in the past decade, with innovative ideas and approaches. The research and findings of this study demonstrated that small, low-lying islands act as the canary in the context of global climate change. The research confirmed the complexity of adaptive capacity of small islands, governed by the socio-ecological interactions of islands. Variations in biogeophysical, socio-economic, socio-cultural and political aspects on islands are unique and relative to their context, forming an integral part of their adaptive capacity. Local variations in adaptive capacity determinants, and their dynamic interplay, determine resilience of islands. While socio-cognitive factors influence the motivation of people for adaptation, governance and institutions are crucial to translate adaptive capacity to adaptive actions. Similarly, household scale adaptive capacity is mobilised through assets, social organisation, and flexibility. A major goal of attempting this study was to understand whether the islands of the Maldives have the adaptive capacity to cope and adjust to future climate change impacts. Even though precise generalities on specific levels of adaptive capacity on islands have not been inferred from the study, the commonalities of how and why islands are more adaptive than others have been found.

References

ADB (Asian Development Bank). (2015). *Maldives: Overcoming the Challenges of a Small Island State*. Manila: Asian Development Bank.

Adger, W. N. (2000). Social and ecological resilience: are they related? *Progress in Human Geography, 24*(3), 347-364. doi:10.1191/030913200701540465

Adger, W. N. (2003). *IHDP Update, 2*(null), 1.

Adger, W. N. (2010). Social Capital, Collective Action, and Adaptation to Climate Change. In M. Voss (Ed.), *Der Klimawandel* (pp. 327-345): VS Verlag für Sozialwissenschaften.

Adger, W. N., Agrawala, S., Mirza, M. M. Q., Conde, C., O'Brien, K., Pulhin, J., . . . Takahashi, K. (2007). Assessment of adaptation practices, options, constraints and capacity. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. v. d. Linden, & C. E. Hanson (Eds.). UK: Cambridge University Press.

Adger, W. N., Arnell, N. W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change, 15*(2), 77-86. doi:https://doi.org/10.1016/j.gloenvcha.2004.12.005

Adger, W. N., Barnett, J., Brown, K., Marshall, N., & O'Brien, K. (2013). Cultural dimensions of climate change impacts and adaptation. *Nature Clim. Change, 3*(2), 112-117.

Adger, W. N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D. R., . . . Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climatic Change, 93*(3-4), 335-354.

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockström, J. (2005). Social-ecological resilience to coastal disasters. *Science, 309*(5737), 1036-1039.

Adger, W. N., J.M. Pulhin, J. Barnett, G.D. Dabelko, G.K. Hovelsrud, M. Levy, Ú. Oswald Spring, and C.H. Vogel,. (2014). *Human security*. Retrieved from Cambridge, United Kingdom and New York, NY, USA,:

Adger, W. N., S. Agrawala, M.M.Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, . . . K. Takahashi. (2007). *Assessment of adaptation practices, options, constraints and capacity. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Retrieved from Cambridge, UK, : https://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch17.html

Adger, W. N., Smith, J. B., Klein, R. J. T., & Huq, S. (2003). Climate Change, Adaptive Capacity and Development.

Adger, W. N., & Vincent, K. (2005). Uncertainty in adaptive capacity. *Comptes rendus - Géoscience, 337*(4), 399-410. doi:10.1016/j.crte.2004.11.004

Adnan, F. A. F., Hamylton, S. M., & Woodroffe, C. D. (2016). A Comparison of Shoreline Changes Estimated Using the Base of Beach and Edge of Vegetation Line at North Keeling Island. *Journal of Coastal Research*, 967-971. doi:10.2112/SI75-194.1

Ahmad, R. A. (2001). The state and national foundation in the Maldives. *Cultural Dynamics, 13*(3), 293-315.

Ahmed, M., & Suphachalasai, S. (2014). *Assessing the costs of climate change and adaptation in South Asia*. Retrieved from Mandaluyong City, Philippines:

Ajibade, I., & McBean, G. (2014). Climate extremes and housing rights: A political ecology of impacts, early warning and adaptation constraints in Lagos slum communities. *Geoforum, 55*, 76-86. doi:http://dx.doi.org/10.1016/j.geoforum.2014.05.005

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour* (Pbk. ed. ed.). Englewood Cliffs, N.J.: Prentice-Hall.

Ali, M. (2000). *Reef Island Geomorphology: Formation Development and Prospectives of Islands in Baa Atoll. South Maalhosmadulu.* (PhD), University of New South Wales,

Alvesson, M. (2003). Beyond neopositivists, romantics, and localists: A reflexive approach to interviews in organisational research. *Academy of Management Review, 28*(1), 13-33.

Amir, H. (2011). *Islamism and radicalism in the Maldives.* Monterey, California. Naval Postgraduate School, Angell, E., & Stokke, K. B. (2014). Vulnerability and adaptive capacity in Hammerfest, Norway. *Ocean & Coastal Management*(0). doi:http://dx.doi.org/10.1016/j.ocecoaman.2013.11.009

Arnall, A., & Kothari, U. (2015). Challenging climate change and migration discourse: Different understandings of timescale and temporality in the Maldives. *Global Environmental Change, 31*, 199-206. doi:http://dx.doi.org/10.1016/j.gloenvcha.2015.01.011

Ashley, C., & Carney, D. (1999). *Sustainable livelihoods: Lessons from early experience* (Vol. 7): Department for International Development London.

Aslam, M., & Kench, P. S. (2017). Reef island dynamics and mechanisms of change in Huvadhoo Atoll, Republic of Maldives, Indian Ocean. *Anthropocene, 18*, 57-68. doi:https://doi.org/10.1016/j.ancene.2017.05.003

Baig, M. H. A. (2009). *The Effect of Eurasian Snow Cover on the Monsoon Rainfall of Pakistan* (Vol. 5).

Bailey, R. T., Jenson, J., & Olsen, A. (2010). Estimating the Ground Water Resources of Atoll Islands. *Water, 2*(1), 1.

Bailey, R. T., Khalil, A., & Chatikavanij, V. (2015). Estimating Current and Future Groundwater Resources of the Maldives. *JAWRA Journal of the American Water Resources Association, 51*(1), 112-122. doi:10.1111/jawr.12236

Bak, O. (2011). The Role of Qualitative Research in a Mixed Methods Study. *Qualitative Research Journal, 11*(2), 76-84.

Bar Human RightsCommittee (BHRC). (2015). *Trial Observation Report - Prosecution of Mohamed Nasheed*. Retrieved from London: http://www.barhumanrights.org.uk

Barnett, J. (2011). Dangerous climate change in the Pacific Islands: food production and food security. *Regional Environmental Change, 11*(1), 229-237. doi:10.1007/s10113-010-0160-2

Barnett, J., & Adger, W. N. (2003). Climate Dangers and Atoll Countries. *Climatic Change, 61*(3), 321-337. doi:10.1023/B:CLIM.0000004559.08755.88

Barnett, J., & Campbell, J. (2010). *Climate Change and Small Island States: Power, Knowledge and the South Pacific*. London: Earthscan.

Beeson, M. (2010). The coming of environmental authoritarianism. *Environmental Politics, 19*(2), 276-294. doi:10.1080/09644010903576918

Belopolsky, A., & Droxler, A. (2003). Imaging Tertiary carbonate system—the Maldives, Indian Ocean: Insights into carbonate sequence interpretation. *The Leading Edge, 22*(7), 646-652. doi:doi:10.1190/1.1599690

Below, T. B., Mutabazi, K. D., Kirschke, D., Franke, C., Sieber, S., Siebert, R., & Tscherning, K. (2012). Can farmers' adaptation to climate change be explained by socio-economic household-level variables? *Global Environmental Change, 22*(1), 223-235. doi:https://doi.org/10.1016/j.gloenvcha.2011.11.012

Benedict, B. (1966). Sociological characteristics of small territories and their implications for economic development. *The Social Anthropology of Complex Societies. London: Tavistock Publications*, 23-36.

Berg, B. L., & Lune, H. (2012). *Qualitative research methods for the social sciences* (Vol. 8th). Boston: Pearson.

Bergsma, E., Gupta, J., & Jong, P. (2012). Does individual responsibility increase the adaptive capacity of society? The case of local water management in the Netherlands. *Resources, Conservation and Recycling, 64*(0), 13-22. doi:http://dx.doi.org/10.1016/j.resconrec.2012.03.006

Berkes, F., Colding, J., & Folke, C. (2003). Synthesis:building resilience and adaptive caacity in social ecological systems. In F. Berkes, J. Colding, & C. Folke (Eds.), *Navigating social-ecological systems: building resilience for complexity and change*. New York: Cambridge University Press.

Binder, C. R., Hinkel, J., Bots, P. W. G., & Pahl-Wostl, C. (2013). Comparison of Frameworks for Analyzing Social-ecological Systems. *Ecology and Society, 18*(4). doi:10.5751/ES-05551-180426

Birk, T. (2014). Assessing vulnerability to climate change and socioeconomic stressors in the Reef Islands group, Solomon Islands. *Geografisk Tidsskrift-Danish Journal of Geography, 114*(1), 59-75. doi:10.1080/00167223.2013.878228

Blaikie, P. (1995). Changing Environments or Changing Views? A Political Ecology for Developing Countries. *Geography, 80*(3), 203-214.
Bohensky, E., Stone-Jovicich, S., Larson, S., & Marshall, N. (2010). Adaptive Capacity in Theory and Reality: Implications for Governance in the Great Barrier Reef Region. In D. Armitage & R. Plummer (Eds.), *Adaptive Capacity and Environmental Governance* (pp. 23-42). Berlin: Springer-Verlag.
Bonnerjee, A. (2014). The Maldives: The shifting nature of a welfare state. In G. Koehler & D. Chopra (Eds.), *Development and Welfare Policy in South Asia*. Hoboken: Taylor and Francis.
Bradley, G. L., & Reser, J. P. (2017). Adaptation processes in the context of climate change: a social and environmental psychology perspective. *Journal of Bioeconomics, 19*(1), 29-51. doi:10.1007/s10818-016-9231-x
Braun, V., Clarke, V., & Terry, G. (2014). Thematic analysis. In Poul Rohleder & Antonia C. Lyons (Eds.), *Qualitative Research in Clinical Health and Psychology* (pp. 95-114). New York: Palgrave MacMillan.
Bremner, L. (2016). Thinking Architecture with an Indian Ocean Aquapelago. *GeoHumanities, 2*(2), 284-310. doi:10.1080/2373566X.2016.1234353
Bridges, K. W., & McClatchey, W. C. (2009). Living on the margin: Ethnoecological insights from Marshall Islanders at Rongelap atoll. *Global Environmental Change, 19*(2), 140-146. doi:https://doi.org/10.1016/j.gloenvcha.2009.01.009
Bruce, C. G., Kelly, P. M., Robert, K., & Ailbhe, T. (2015). Introduction. In C. G. Bruce, P. M. Kelly, K. Robert, & T. Ailbhe (Eds.), *Climate Change and the Coast* (pp. 3-28). Boca Raton, FL: CRC Press.
Bussey, M., Roiko, A., Sano, M., Thomsen, D. C., Weber, E., Smith, T. F., . . . Richards, R. (2012). Framing adaptive capacity through a history–futures lens: Lessons from the South East Queensland Climate Adaptation Research Initiative. *Futures, 44*(4), 385-397. doi:10.1016/j.futures.2011.12.002
Buttel, F. H., & Humphrey, C. R. (2001). Sociological Theory and the Natural Environment. In R. E. Dunlap & W. Michelson (Eds.), *Handbook of Environmental Sociology*: Greenwood.
Byg, A., & Salick, J. (2009). Local perspectives on a global phenomenon—Climate change in Eastern Tibetan villages. *Global Environmental Change, 19*(2), 156-166. doi:https://doi.org/10.1016/j.gloenvcha.2009.01.010
Carmen, E.-B., Glavovic, B. C., & Robert, K. (2015). A tale of two atoll nations: A comparison of risk, resilience, and adaptive response of Kiribati and the Maldives. In B. C. Glavovic, P. M. Kelly, K. Robert, & T. Ailbhe (Eds.), *Climate Change and the Coast* (pp. 313-336). Boca Raton, FL: CRC Press.
Chen, M., Sun, F., Berry, P., Tinch, R., Ju, H., & Lin, E. (2014). Integrated assessment of China's adaptive capacity to climate change with a capital approach. *Climatic Change, 128*(3), 367-380. doi:10.1007/s10584-014-1163-7
Church, J. A., White, N. J., & Hunter, J. R. (2006). Sea-level rise at tropical Pacific and Indian Ocean islands. *Global and Planetary Change, 53*(3), 155-168. doi:http://dx.doi.org/10.1016/j.gloplacha.2006.04.001
Cinner, J. E., Adger, W. N., Allison, E. H., Barnes, M. L., Brown, K., Cohen, P. J., . . . Morrison, T. H. (2018). Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change*. doi:10.1038/s41558-017-0065-x
Cinner, J. E., McClanahan, T. R., Graham, N. A. J., Daw, T. M., Maina, J., Stead, S. M., . . . Bodin, Ö. (2012). Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. *Global Environmental Change, 22*(1), 12-20. doi:http://dx.doi.org/10.1016/j.gloenvcha.2011.09.018
Collins, K. M. T., Onwuegbuzie, A. J., & Jiao, Q. G. (2007). A Mixed Methods Investigation of Mixed Methods Sampling Designs in Social and Health Science Research. *Journal of Mixed Methods Research, 1*(3), 267-294. doi:10.1177/1558689807299526
Collins, K. M. T., Onwuegbuzie, A. J., & Sutton, I. L. (2006). A model incorporating the rationale and purpose for conducting mixed methods research in special education and beyond. *Learning Disabilities: A Contemporary Journal, 4*, 67-100.
Comrey, A. L. (1973). *A first course in factor analysis*. New York: Academic Press.

Connell, J. (2013). *Islands at risk? : environments, economies and contemporary change*. Cheltenham, UK: Edward Elgar Publishing.
Cote, M., & Nightingale, A. J. (2012). Resilience thinking meets social theory: Situating social change in socio-ecological systems (SES) research. *Progress in Human Geography, 36*(4), 475-489. doi:10.1177/0309132511425708
Cox, D. C. (1951). The hydrology of Arno Atoll, Marshall Islands. *Atoll Research Bulletin*(8), 29.
Creswell, J. W. (2013). *Qualitative inquiry and research design: choosing among five approaches* (Vol. 3rd). Thousand Oaks, Calif: SAGE Publications.
Creswell, J. W. (2014). *Research Design, qualitative, quantitative and mixed methods approaches* (4th ed.). London: Sage Publications Inc.
Cumming, G. S. (2011). Conceptual Background on Social-Ecological Systems and Resilience. In *Spatial Resilience in Social-Ecological Systems* (pp. 7-33). Dordrecht: Springer Netherlands.
Davidson, D. (2012). Analysing responses to climate change through the lens of reflexivity. *The British Journal of Sociology, 63*(4), 616-640. doi:10.1111/j.1468-4446.2012.01429.x
Davoudi, S., Shaw, K., Haider, L. J., Quinlan, A. E., Peterson, G. D., Wilkinson, C., . . . Davoudi, S. (2012). Resilience: A Bridging Concept or a Dead End? "Reframing" Resilience: Challenges for Planning Theory and Practice Interacting Traps: Resilience Assessment of a Pasture Management System in Northern Afghanistan Urban Resilience: What Does it Mean in Planning Practice? Resilience as a Useful Concept for Climate Change Adaptation? The Politics of Resilience for Planning: A Cautionary Note. *Planning Theory & Practice, 13*(2), 299-333. doi:10.1080/14649357.2012.677124
De Souza, R.-M. (2016). Corruption, Climate Change, and Vulnerability in Small Island States. Retrieved from https://www.wilsoncenter.org/article/corruption-climate-change-and-vulnerability-small-island-states
Deng, C., & Bailey, R. T. (2017). Assessing groundwater availability of the Maldives under future climate conditions. *Hydrological Processes, 31*(19), 3334-3349. doi:10.1002/hyp.11246
Dietz, T., & Rosa, E. A. (2001). Human Dimensions of Global Environmental Change. In R. E. Dunlap & W. Michelson (Eds.), *Handbook of Environmental Sociology*: Greenwood.
Douglas, M. (1994). *Risk and Blame : Essays in Cultural Theory*. London: Taylor and Francis.
Dovers, S. (1999). Adaptive Policy, Institutions and Management: Challenges for Lawyers and Others. *Griffith Law Review, 8*(2), 374-393.
Dow, K., Berkhout, F., Preston, B. L., Klein, R. J. T., Midgley, G., & Shaw, M. R. (2013). Limits to adaptation. *Nature Climate Change, 3*, 305. doi:10.1038/nclimate1847
Duchhart, I. (2007). *Designing Sustainable Landscapes: From Experience to Theory, Process of Reflective Learning from Case-study Projects in Kenya*. Retrieved from Netherlands:
Dumay, J., & Qu, S. Q. (2011). The qualitative research interview. *Qualitative research in accounting & management, 8*(3), 238-264. doi:10.1108/11766091111162070
Dunlap, R. E., & Catton, W. R., Jr. (1994). Struggling with Human Exemptionalism: The Rise, Decline and Revitalization of Environmental Sociology. *The American Sociologist, 25*(1), 5-30. doi:10.2307/27698675
Dunlap, R. E., & Jones, R. E. (2001). Environmental Concern: Conceptual and Measurement Issues. In R. E. Dunlap & W. Michelson (Eds.), *Handbook of Environmental Sociology*: Greenwood.
Eakin, H., & Luers, A. L. (2006). Assessing the vulnerability of social-environmental systems. In *Annual Review of Environment and Resources* (Vol. 31, pp. 365-394). Palo Alto: Annual Reviews.
Eguavoen, I., Schulz, K., De Wit, S., Weisser, F., & Müller-Mahn, D. (2015). Political Dimensions of Climate Change Adaptation: Conceptual Reflections and African Examples. In W. Leal Filho (Ed.), *Handbook of Climate Change Adaptation* (pp. 1184-1199). Berlin, Heidelberg: Springer Berlin Heidelberg.
Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing, 62*(1), 107-115. doi:10.1111/j.1365-2648.2007.04569.x
Elrick-Barr, C., Glavovic, B., & Kay, R. (2015). A tale of two atoll nations: A comparison of risk, resilience, and adaptive response of Kiribati and the Maldives. In *Climate Change and the Coast* (pp. 313-336): CRC Press.

Elwood, S. (2010). Mixed Methods: Thinking, Doing, and Asking in Multiple Ways. In D. DeLyser, S. Herbert, S. Aitken, M. Crang, & L. McDowell (Eds.), The SAGE handbook of qualitative geography. Thousand Oaks, Calif;London, UK;: SAGE.
Engle, N. L. (2011). Adaptive capacity and its assessment. *Global Environmental Change, 21*(2), 647-656. doi:http://dx.doi.org/10.1016/j.gloenvcha.2011.01.019
Engle, N. L., & Lemos, M. C. (2010). Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil. *Global Environmental Change, 20*(1), 4-13. doi:http://dx.doi.org/10.1016/j.gloenvcha.2009.07.001
Eriksen, S. (2010). Governance for sustainable adaptation? Environmental stressors, natural resources and human security. In *Climate governance and development*: World Bank Publications.
Escobar, A. (1998). Whose Knowledge , Whose nature ? Biodiversity , Conservation , and the Political Ecology of Social Movements. *Journal of Political Ecology, 5*(1), 53-82.
Espinosa, A., & Walker, J. (2011). *COMPLEXITY APPROACH TO SUSTAINABILITY*. River Edge, SG: Imperial College Press.
Etkin, D., & Ho, E. (2007). Climate Change: Perceptions and Discourses of Risk. *Journal of Risk Research, 10*(5), 623-641. doi:10.1080/13669870701281462
Falkland, T. (2001). Report on Groundwater Investigations in Northern Development Region (ADB Regional Development Project). *Report for Ministry of Planning and National Development, Male, Republic of Maldives*.
Fallati, L., Savini, A., Sterlacchini, S., & Galli, P. (2017). Land use and land cover (LULC) of the Republic of the Maldives: first national map and LULC change analysis using remote-sensing data. *Environmental Monitoring and Assessment, 189*(8), 417. doi:10.1007/s10661-017-6120-2
Fathih, M. S. (2016, 4th February). Translation of President Yameen's 2016 Presidential Address. Retrieved from http://maldivesindependent.com/politics/translation-of-the-2016-presidential-address-at-the-peoples-majlis-opening-121984
Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. *International Journal of Qualitative Methods, 5*(1), 80-92. doi:doi:10.1177/160940690600500107
Fernandes, R., & Pinho, P. (2017). The distinctive nature of spatial development on small islands. *Progress in Planning, 112*(Supplement C), 1-18. doi:https://doi.org/10.1016/j.progress.2015.08.001
Field, A. P. (2013). *Discovering statistics using IBM SPSS Statistics: and sex and drugs and rock 'n' roll* (4th ed.). London: Sage Publications Ltd.
Figueres, C. (2013). Climate policy: a new foundation of stability and prosperity. *Climate Policy, 13*(5), 538-540. doi:10.1080/14693062.2013.822736
Finlay, L. (n.d.). An introduction to phenomenology applied to research. Retrieved from http://lindafinlay.co.uk/phenomenology/
Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change, 16*(3), 253-267. doi:http://dx.doi.org/10.1016/j.gloenvcha.2006.04.002
Folke, C., & Berkes, F. (2000). *Linking social and ecological systems: management practices and social mechanisms for building resilience*. Cambridge: Cambridge University Press.
Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. *AMBIO: A Journal of the Human Environment, 31*(5), 437-440. doi:10.1579/0044-7447-31.5.437
Forbes, D. L., James, T. S., Sutherland, M., & Nichols, S. E. (2013). Physical basis of coastal adaptation on tropical small islands. *Sustainability Science, 8*(3), 327-344. doi:10.1007/s11625-013-0218-4
Ford, J. D., Keskitalo, E., Smith, T., Pearce, T., Berrang-Ford, L., Duerden, F., & Smit, B. (2010). Case study and analogue methodologies in climate change vulnerability research. *Wiley Interdisciplinary Reviews: Climate Change, 1*(3), 374-392.
Ford, M. (2012). Shoreline Changes on an Urban Atoll in the Central Pacific Ocean: Majuro Atoll, Marshall Islands. *Journal of Coastal Research*, 11-22. doi:10.2112/jcoastres-d-11-00008.1

Ford, M. (2013). Shoreline changes interpreted from multi-temporal aerial photographs and high resolution satellite images: Wotje Atoll, Marshall Islands. *Remote Sensing of Environment, 135*, 130-140. doi:https://doi.org/10.1016/j.rse.2013.03.027
Freduah, G., Fidelman, P., & Smith, T. F. (2018). Mobilising adaptive capacity to multiple stressors: Insights from small-scale coastal fisheries in the Western Region of Ghana. *Geoforum, 91*, 61-72. doi:10.1016/j.geoforum.2018.02.026
Friedel, M. H. (1991). Range Condition Assessment and the Concept of Thresholds: A Viewpoint. *Journal of Range Management, 44*(5), 422-426. doi:10.2307/4002737
Fröhlich, J., & Knieling, J. (2013). Conceptualising Climate Change Governance. In J. Knieling & W. Leal Filho (Eds.), *Climate Change Governance* (pp. 9-26). Berlin, Heidelberg: Springer Berlin Heidelberg.
Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age. *Futures, 25*(7), 739-755. doi:http://dx.doi.org/10.1016/0016-3287(93)90022-L
Gilley, B. (2012). Authoritarian environmentalism and China's response to climate change. *Environmental Politics, 21*(2), 287-307. doi:10.1080/09644016.2012.651904
Glavovic, B. C. (2015). On the frontline in the Anthropocne: Adapting to climate change through deliberative coastal goverannce.. In B. C. Glavovic, P. M. Kelly, K. Robert, & T. Ailbhe (Eds.), *Climate Change and the Coast* (pp. 51-75). Boca Raton, FL: CRC Press.
Goldman, M. J., & Riosmena, F. (2013). Adaptive capacity in Tanzanian Maasailand: Changing strategies to cope with drought in fragmented landscapes. *Global Environmental Change, 23*(3), 588-597. doi:http://dx.doi.org/10.1016/j.gloenvcha.2013.02.010
Goulden, M. C., Adger, W. N., Allison, E. H., & Conway, D. (2013). Limits to Resilience from Livelihood Diversification and Social Capital in Lake Social–Ecological Systems. *Annals of the Association of American Geographers, 103*(4), 906-924. doi:10.1080/00045608.2013.765771
Granderson, A. A. (2014). Making sense of climate change risks and responses at the community level: A cultural-political lens. *Climate Risk Management, 3*, 55-64. doi:http://dx.doi.org/10.1016/j.crm.2014.05.003
Gray, S., & Foran, J. (2015). Climate Injustice: The Real History of the Maldives. *Berkeley Journal of Sociology, 59*, 14-25.
Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a Conceptual Framework for Mixed-Method Evaluation Designs. *Educational Evaluation and Policy Analysis, 11*(3), 255-274. doi:10.2307/1163620
Grothmann, T., & Patt, A. (2005a). *Adaptive capacity and human cognition*. Paper presented at the Open Meeting of the Global Environmental Change Research Community, Montreal, Canada
Grothmann, T., & Patt, A. (2005b). Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change, 15*(3), 199-213. doi:http://dx.doi.org/10.1016/j.gloenvcha.2005.01.002
Grothmann, T., & Reusswig, F. (2006). People at Risk of Flooding: Why Some Residents Take Precautionary Action While Others Do Not. *Natural Hazards, 38*(1), 101-120. doi:10.1007/s11069-005-8604-6
Gunderson, L. H. (2003). Adaptive dancing: Interactions between social resilience and ecological cises. In F. Berkes, J. Colding, & C. Folke (Eds.), *Navigating social-ecological systems: building resilience for complexity and change*. New York: Cambridge University Press.
Gupta, J., Termeer, C., Klostermann, J., Meijerink, S., van den Brink, M., Jong, P., . . . Bergsma, E. (2010). The Adaptive Capacity Wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science & Policy, 13*(6), 459-471. doi:http://dx.doi.org/10.1016/j.envsci.2010.05.006
Han, H. (2015). Authoritarian environmentalism under democracy: Korea's river restoration project. *Environmental Politics, 24*(5), 810-829. doi:10.1080/09644016.2015.1051324
Hau'ofa, E. (1993). Our sea of islands. In V. Naidu, E. Waddel, & E. Hau'ofa (Eds.), *A new Oceania: Rediscovering our sea of islands* (pp. 2-16). Suva: University of the South Pacific.
Hay, P. (2006). A Phenomenology of Islands. *Island Studies Journal, 1*(1), 19-42.

Herbert, S. (2000). For ethnography. *Progress in Human Geography, 24*(4), 550-568. doi:10.1191/030913200100189102
Hinkel, J. (2011). “Indicators of vulnerability and adaptive capacity”: Towards a clarification of the science–policy interface. *Global Environmental Change, 21*(1), 198-208. doi:http://dx.doi.org/10.1016/j.gloenvcha.2010.08.002
Hochstetler, K. (2012). Democracy and the Environemnt in Latin America and Eastern Europe. In P. F. Steinberg & S. D. VanDeveer (Eds.), *Comparative Environmental Politics: Theory, Practice and Prospects*. Cambridge, MA: MIT Press.
Hogarth, J. R., & Wójcik, D. (2016). An Evolutionary Approach to Adaptive Capacity Assessment: A Case Study of Soufriere, Saint Lucia. *Sustainability, 8*(3), 228.
Holling, C. S. (1973). *Annual Review of Ecological Systems, 4*(null), 1.
Holling, C. S., & Gunderson, L. H. (2002). Resilience and Adaptive Cycles. In C. S. Holling & L. H. Gunderson (Eds.), *Panarchy: understanding transformations in human and natural systems* (pp. 25-62). Washington, DC: Island Press.
Hopley, D. (1993). *Pacific Islands : origin and ecology / David Hopley & John O'Brien*. [Townsville, Qld: James Cook University and Unesco].
Houtkoop-Steenstra, H. (2000). *Interaction and the Standardized Survey Interview: The Living Questionnaire*. New York: Cambridge University Press.
Husain, M. (1976). The Rehla of Ibn Battuta - India, Maldive Islands and Ceylon - translation and commentary. In. Baroda, India: Oriental Institute.
Ibrahim, S. A., Bari, M. R., & Miles, L. (2002). *Water Resources Management in Maldives with an Emphasis on Desalination*. Retrieved from Male', Republic of Maldives:
Ingold, T. (2000). *The perception of the environment: essays on livelihood, dwelling and skill*: Psychology Press.
Intergovernmental Panel on Climate Change. (2001). *TECHNICAL SUMMARY:climate change 2001:impacts, adaptation and vulnerability*. Retrieved from http://www.grida.no/climate/ipcc_tar/wg2/pdf/wg2TARtechsum.pdf
Intergovernmental Panel on Climate Change. (2007). *IPCC Working Group II Fourth Assessment Report*. Retrieved from Geneva:
Intergovernmental Panel on Climate Change. (2012). *Summary for policymakers. In Managing the risks of extreme events and disasters to advance climate change adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*. Retrieved from UK:
Intergovernmental Panel on Climate Change. (2014a). *Climate change 2013: the physical science basis: Working Group I contribution to the Fifth assessment report of the Intergovernmental Panel on Climate Change* (110705799X). Retrieved from Cambridge, United Kingdom and New York, NY, USA,:
Intergovernmental Panel on Climate Change. (2014b). *Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Retrieved from Cambridge, United Kingdom and New York, NY, USA:
Intergovernmental Panel on Climate Change. (2014c). *Working Group II contribution to the IPCC Fifth Assessment Report (AR5), Climate Change 2014: Impacts, Adaptation and Vulnerability* Retrieved from UK:
Jacobs, B., Nelson, R., Kuruppu, N., & Leith, P. (2015). An adaptive capacity guide book: Assessing, building and evaluating the capacity of communities to adapt in a changing climate. *Southern Slopes Climate Change Adaptation Research Partnership (SCARP), University of Technology Sydney and University of Tasmania. Hobart, Tasmania. ISBN: 9781862958272*.
Johnson, R. B. (Producer). (2014). Mixed methods research design and analysis with validity: A primer. [Powerpoint Slides]
Johnson, R. B., & Gray, R. (2010). A history of philosophical and theoretical issues for mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (Second ed., pp. 69-94). CA: Thosand Oaks; Sage.

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research, 1*(2), 112-133. doi:10.1177/1558689806298224

Johnston, M., & Hesseln, H. (2012). Climate change adaptive capacity of the Canadian forest sector. *Forest Policy and Economics, 24*(0), 29-34. doi:http://dx.doi.org/10.1016/j.forpol.2012.06.001

Jones, L. (2011a). *Towards a holistic conceptualisation of adaptive capacity at the local level: insights from the Local Adaptive Capacity framework (LAC)*. Paper presented at the Building Livelihoods Resilience in a Changing Climate' Conference, Kuala Lumpur.

Jones, L. (2011b). Towards a holistic conceptualisation of adaptive capacity at the local level: insights from the Local Adaptive Capacity framework (LAC). *Kuala Lumpur: ODI*.

Jones, L., Ludi, E., & Levine, S. (2010a). Towards a characterisation of adaptive capacity: a framework for analysing adaptive capacity at the local level. In. London: Overseas Development Institute.

Jones, L., Ludi, E., & Levine, S. (2010b). Towards a characterisation of adaptive capacity: a framework for analysing adaptive capacity at the local level, Overseas Development Institute. In.

Karthikheyan, T. C. (2010). Environmental Challenges for Maldives. *South Asian Survey, 17*(2), 343-351. doi:10.1177/097152311201700210

Keith, F. P. (Ed.) (2003). *Introduction and Purpose. Survey Research. SAGE Publications Ltd*. London, England: SAGE Publications Ltd.

Kelman, I. (2014). No change from climate change: vulnerability and small island developing states. *The Geographical Journal, 180*(2), 120-129. doi:10.1111/geoj.12019

Kelman, I., & Khan, S. (2013). Progressive climate change and disasters: island perspectives. *Natural Hazards, 69*(1), 1131-1136. doi:10.1007/s11069-013-0721-z

Kelman, I., & West, J. J. (2009). Climate change and small island developing states: a critical review. *Ecological and Environmental Anthropology, 5*(1), 1-16.

Kench, P. S. (2011). Maldives. In *Encyclopedia of Modern Coral Reefs* (pp. 648-653): Springer.

Kench, P. S. (2012). Compromising reef island shoreline dynamics: legacies of the engineering paradigm in the Maldives. In *Pitfalls of Shoreline Stabilization* (pp. 165-186): Springer.

Khaleel, Z. (2017). [Existence and operation of Climate Change Advisory Council].

Kim, E.-s. (2016). The politics of climate change policy design in Korea. *Environmental Politics, 25*(3), 454-474. doi:10.1080/09644016.2015.1104804

Kingdon, J. W. (1993). How do Issues Get on Public Policy Agenda. In W. J. Wilson (Ed.), *Sociology and the Public Policy Agenda* (pp. 40-50). Newbury Park, CA: SAGE Publications, Inc.

Kotnik, Ž., & Klun, M. (2013). *Constructing composite environmental indicators*. Paper presented at the 16thToulon-Verona Conference" Excellence in Services", Slovenia.

Lata, S., & Nunn, P. (2012). Misperceptions of climate-change risk as barriers to climate-change adaptation: a case study from the Rewa Delta, Fiji. *Climatic Change, 110*(1), 169-186. doi:10.1007/s10584-011-0062-4

Latheefa, A., Shafia, A., & Shafeega, F. (2011). *State of the Environment Maldives 2011*. Maldives: Government of Maldives.

Layder, D. (2013). *Overview of the Adaptive Approach. Doing Excellent Small-Scale Research. SAGE Publications Ltd*. London: SAGE Publications Ltd.

Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C.-Y., & Leiserowitz, A. A. (2015). Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change, 5*, 1014. doi:10.1038/nclimate2728

Lemos, M. C., & Agrawal, A. (2006). Environmental Governance. *Annual Review of Environment and Resources, 31*(1), 297-325. doi:10.1146/annurev.energy.31.042605.135621

Lemos, M. C., Bell, A. R., Engle, N. L., Formiga-Johnsson, R. M., & Nelson, D. R. (2010). Technical knowledge and water resources management: A comparative study of river basin councils, Brazil. *Water Resources Research, 46*(6), n/a-n/a. doi:10.1029/2009WR007949

Lenton, T. M., Held, H., Kriegler, E., Hall, J. W., Lucht, W., Rahmstorf, S., & Schellnhuber, H. J. (2008). Tipping elements in the Earth's climate system. *Proceedings of the National Academy of Sciences, 105*(6), 1786-1793. doi:10.1073/pnas.0705414105

Levin, S. A., & Clark, W. C. (2010). *Toward a Science of Sustainability: Report from Toward a Science of Sustainability Conference; Airlie Center~ Warrenton, Virginia*. Retrieved from

Linting, M., & van der Kooij, A. (2012). Nonlinear Principal Components Analysis With CATPCA: A Tutorial. *Journal of Personality Assessment, 94*(1), 12-25. doi:10.1080/00223891.2011.627965

Malatesta, S., & Schmidt di Friedberg, M. (2017). Environmental policy and climate change vulnerability in the maldives: From the 'lexicon of risk' to social response to change. *Island Studies Journal, 12*(1), 53-70. doi:http://dx.doi.org/10.24043/isj.5

Maldonado, J. H., & Moreno-Sanchez, R. d. P. (2014). Estimating the Adaptive Capacity of Local Communities at Marine Protected Areas in Latin America: a Practical Approach. *Ecology and Society, 19*(1). doi:10.5751/ES-05962-190116

Maloney, C. (1976). The Maldives: New Stresses in an Old Nation. *Asian Survey, 16*(7), 654-671. doi:10.2307/2643164

Manik, A. H. H. (1999). The story of 20th century 'famines' in Maldives Retrieved from http://www.maldivesculture.com/index.php?option=com_content&task=view&id=34&Itemid=83

Manik, A. H. H. (2000). Voraa viyafaariverin *Furadhaana*.

Manik, A. U. (2012). *Alhuganduge Dhuvahu Foiy 1947-2008*. In (pp. 680).

Mann, T., Bayliss-Smith, T., & Westphal, H. (2016). A geomorphic interpretation of shoreline change rates on reef islands. *Journal of Coastal Research, 32*, 500+.

Marshall, N. A., Marshall, P. A., Tamelander, J., Obura, D., Malleret-King, D., & Cinner, J. E. (2009). *A Framework for Social Adaptation to Climate Change; Sustaining Tropical Coastal Communities and Industries*. Retrieved from Gland, Switzerland:

Maxwell, J. A. (1992). Understanding and Validity in Qualitative Research. *Harvard Educational Review, 62*(3), 279.

May, J. F. (2016). *Maldives' Population Dynamics: Policy Prospects for Human Growth and Opportunity*. Retrieved from Maldives: http://statisticsmaldives.gov.mv/nbs/wp-content/uploads/2016/07/Population-Dynamics-Report.pdf.

Mayntz, R. (2007). *The architecture of multi-level governance of economic sectors* (No. 07/13). Retrieved from Köln: http://hdl.handle.net/10419/36520

McClanahan, T. R., & Cinner, J. (2011). Linking social, ecological and environmental systems. In *Adapting to a Changing Environment: Confronting the Consequences of Climate Change* (pp. 208-220). UK: Oxford University Press.

McConnell, A. (2010). Policy Success, Policy Failure and Grey Areas In-Between. *Journal of Public Policy, 30*(03), 345-362. doi:doi:10.1017/S0143814X10000152

McCright, A. M., & Dunlap, R. E. (2011). THE POLITICIZATION OF CLIMATE CHANGE AND POLARIZATION IN THE AMERICAN PUBLIC'S VIEWS OF GLOBAL WARMING, 2001–2010. *Sociological Quarterly, 52*(2), 155-194. doi:10.1111/j.1533-8525.2011.01198.x

McDonald, R. I., Chai, H. Y., & Newell, B. R. (2015). Personal experience and the 'psychological distance' of climate change: An integrative review. *Journal of Environmental Psychology, 44*(Supplement C), 109-118. doi:https://doi.org/10.1016/j.jenvp.2015.10.003

McLean, R. (2011). Atoll Islands (Motu). In D. Hopley (Ed.), *Encyclopedia of Modern Coral Reefs: Structure, Form and Process* (pp. 47-51). Dordrecht: Springer Netherlands.

McLean, R., & Kench, P. (2015). Destruction or persistence of coral atoll islands in the face of 20th and 21st century sea-level rise? *Wiley Interdisciplinary Reviews: Climate Change, 6*(5), 445-463. doi:10.1002/wcc.350

McNamara, K. E., Smithers, S. G., Westoby, R., & Parnell, K. (2012). *Limits to climate change adaptation for low-lying communities in the Torres Strait*. Retrieved from Gold Coast: https://www.nccarf.edu.au/sites/default/files/attached_files_publications/McNamara_2012_Limits_Torres_Strait_0.pdf

MEE (Ministry of Environment and Energy). (2012). *State of the Environment Maldives 2011*. Maldives: Government of Maldives.

MEE (Ministry of Environment and Energy). (2015a). *Development of high-resolution regional climate model for the Maldives*. Retrieved from Maldives:

MEE (Ministry of Environment and Energy). (2015b). *Survey of Climate Change Adaptation Measures in Maldives.* Retrieved from Maldives: http://www.mv.undp.org/content/maldives/en/home/library/environment_energy/Survey_of_Climate_Change_Adaptation_Measures_in_Maldives.html

MEE (Ministry of Environment and Energy). (2016a). *Maldives Climate Change Policy Framework*. Male', Maldives: Ministry of Environment and Energy.
MEE (Ministry of Environment and Energy). (2016b). *Second National Communication of Maldives to the United Nations Framework Convention on Climate Change*. Retrieved from Maldives:
MEEW (Ministry of Environment Energy and Water). (2007a). *Dhivehi Raajeeyge Thimaavesheege Tharaqee 1978 - 2007*. Male', Maldives: Ministry of Environment Energy and Water.
MEEW (Ministry of Environment Energy and Water). (2007b). *National Adaptation Programme of Action*. Male', Maldives: Ministry of Environment, Energy and Water.
Mengel, M., Nauels, A., Rogelj, J., & Schleussner, C.-F. (2018). Committed sea-level rise under the Paris Agreement and the legacy of delayed mitigation action. *Nature Communications, 9*(1), 601. doi:10.1038/s41467-018-02985-8
MFT (Ministry of Finance and Treasury). (2017). *Statistical Pocket Book of Maldives [online] (2016)*. Maldives: Ministry of Finance and Treasury Retrieved from statisticsmaldives.gov.mv/nbs/wp-content/uploads/2017/01/Statistical-Pocketbook-2016-final-10-Jan-2016.pdf.
MHAHE (Ministry of Home Affairs Housing and Environment). (1999). *Second National Environment Action Plan*. Male': Ministry of Home Affairs, Housing and Environment.
MHAHE (Ministry of Home Affairs Housing and Environment). (2001). *State of the Environment Report Maldives*. Male', Maldives: Ministry of Home Affairs, Housing and Environment.
Millenium Ecosystem Assessment. (2005). *Living Beyond Our Means: Natural Assets and Human Well-being (Statement of the MA Board)*. Retrieved from Washington, DC:
Milligan, P., Njie, A., & Bennett, S. (2004). Comparison of two cluster sampling methods for health surveys in developing countries. *International Journal of Epidemiology, 33*(3), 469-476. doi:10.1093/ije/dyh096
Mimura, N., Nurse, L., McLean, R. F., Agard, J., Briguglio, L., Lefale, P., . . . Sem, G. (2007). Small islands. Climate Change 2007: Impacts, Adaptation and Vulnerability. . In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. v. d. Linden, & C. E. Hanson (Eds.), *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 687-716.). Cambridge, UK,: Cambridge University Press.
Ministry of Environment and Energy. (2015). *Development of a high resolution regional climate model: Climate change scenarios and their interpretation for the Maldives*. Maldives: Ministry of Environment and Energy.
Ministry of Housing Transport and Environment. (2009). *Maldives National Strategy for Sustainable Development*. Maldives: Ministry of Housing, Transport and Environment.
Mohamed, I., & King, D. (2017). Legacy of Authoritative Environmentalism and Path-Dependent Historic Institutionalism in the Climate Change Policy Dynamics of the Maldives. In W. Leal Filho (Ed.), *Climate Change Research at Universities: Addressing the Mitigation and Adaptation Challenges* (pp. 211-231). Cham: Springer International Publishing.
Moreno-Sánchez, R. d. P., & Maldonado, J. H. (2013). Adaptive Capacity of Fishing Communities at Marine Protected Areas: A Case Study from the Colombian Pacific. *Ambio, 42*(8), 985-996. doi:10.1007/s13280-013-0454-y
Morgan, D. L. (1996). Focus Groups. *Annual Review of Sociology, 22*(1), 129-152. doi:doi:10.1146/annurev.soc.22.1.129
Morrison, C., & Pickering, C. (2013). Limits to Climate Change Adaptation: Case Study of the Australian Alps. *Geographical Research, 51*(1), 11-25. doi:10.1111/j.1745-5871.2012.00758.x
Mortreux, C., & Barnett, J. (2017). Adaptive capacity: exploring the research frontier. *Wiley Interdisciplinary Reviews: Climate Change, 8*(4). doi:10.1002/wcc.467
Moser, C., & Stein, A. (2011). Implementing urban participatory climate change adaptation appraisals: a methodological guideline. *Environment and Urbanisation, 23*(2), 463-485. doi:10.1177/0956247811418739
Motesharrei, S., Rivas, J., & Kalnay, E. (2014). Human and nature dynamics (HANDY): Modeling inequality and use of resources in the collapse or sustainability of societies. *Ecological Economics, 101*(0), 90-102. doi:http://dx.doi.org/10.1016/j.ecolecon.2014.02.014
MPHRE (Ministry of Planning Human Resources and Environment). (1990). *National Environment Action Plan*. Male: Ministry of Planning, Human Resources and Environment

MPHRE (Ministry of Planning Human Resources and Environment). (1994). *State of the Environment Maldives*. Male': Ministry of Planning, Human Resources and Environment.
Mulberry, M. (2012, July). The Maldives - From Dictatorship to Democracy, and Back? Retrieved from https://www.nonviolent-conflict.org/maldives-dictatorship-democracy-back/
Nardo, M., M. Saisana, A. Saltelli, S. Tarantola, A. Hoffman, & Giovannini, E. (2008). Hand Book on Construction Composite Indicators: Methodology and User Guide. In N. Michela, S. Michaela, S. Andrea, T. Stefano, H. Anders, & G. Enrico (Eds.). Paris, France Organisation for Economic Co-operation and Development (OECD). Retrieved from http://www.oecd.org/std/42495745.pdf.
Naseem, A. (2016, 11th May). Yameen's (?) Maldives. Retrieved from http://www.dhivehisitee.com/executive/yameen-maldives/
Naseer, A. (2006). *Pre-and post-tsunami coastal planning and land-use policies and issues in the Maldives.* Paper presented at the Workshop on coastal area planning and management in Asian tsunami-affected countries, Bangkok.
Naseer, A., & Hatcher, B. G. (2004). Inventory of the Maldives' coral reefs using morphometrics generated from Landsat ETM+ imagery. *Coral Reefs, 23*(1), 161-168. doi:10.1007/s00338-003-0366-6
Nasheed, M. (1993). *Dhangadu Dhahanaa*. Maldives: Loamaafaanu Publishers.
Naylor, A. K. (2015). Island morphology, reef resources, and development paths in the Maldives. *Progress in Physical Geography, 39*(6), 728-749. doi:10.1177/0309133315598269
Neeraj, V., & Robert, E. R. (2001). Climate change in the Western Himalayas of India: a study of local perception and response. *Climate Research, 19*(2), 109-117.
Nelson, R., Kokic, P., Crimp, S., Martin, P., Meinke, H., Howden, S. M., . . . Nidumolu, U. (2010). The vulnerability of Australian rural communities to climate variability and change: Part II—Integrating impacts with adaptive capacity. *Environmental Science & Policy, 13*(1), 18-27. doi:http://dx.doi.org/10.1016/j.envsci.2009.09.007
Newell, B., Crumley, C. L., Hassan, N., Lambin, E. F., Pahl-Wostl, C., Underdal, A., & Wasson, R. (2005). A conceptual template for integrative human–environment research. *Global Environmental Change, 15*(4), 299-307. doi:http://dx.doi.org/10.1016/j.gloenvcha.2005.06.003
Nhuan, M. T., Tue, N. T., Hue, N. T. H., Quy, T. D., & Lieu, T. M. (2016). An indicator-based approach to quantifying the adaptive capacity of urban households: The case of Da Nang city, Central Vietnam. *Urban Climate, 15*, 60-69. doi:https://doi.org/10.1016/j.uclim.2016.01.002
Nicholls, R. J., Wong, P. P., Burkett, V. R., Codignotto, J. O., Hay, J. E., & McLean, R. F. (2007). *Coastal systems and low-lying areas. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Retrieved from UK:
Nurse, L. A., MClean, R. F., Agard, J., Briguglio, L. P., Duvat-Magnan, V., Pelesikoti, N., . . . Webb, A. (2014). *Small islands. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.* . Retrieved from Cambridge, United Kingdom and New York, NY, USA:
Nyamwanza, A. M. (2012). Livelihood resilience and adaptive capacity : a critical conceptual review : original research*4*(1), 1-6. Retrieved from http://reference.sabinet.co.za/webx/access/electronic_journals/jemba/jemba_v4_n1_a8.pdf
O'Brien, M. J., & Holland, T. D. (1992). The Role of Adaptation in Archaeological Explanation. *American Antiquity, 57*(1), 36-59. doi:10.2307/2694834
O'Shea, M. (2009). Maldives under Abdul Majeed, Hassan Fareed and Mohamed Ameen 1924-1953. Retrieved from http://www.maldivesculture.com/index.php?option=com_content&task=view&id=122&Itemid=79
Obeng, P. A., & Agyenim, J. B. (2013). Climate Change Adaptation: Institutional Approaches for Developing Countries. In J. Knieling & W. Leal Filho (Eds.), *Climate Change Governance* (pp. 185-203). Berlin, Heidelberg: Springer Berlin Heidelberg.
Onwuegbuzie, A. J. (2000). *Expanding the Framework of Internal and External Validity in Quantitative Research*. Paper presented at the Annual Meeting of the Association for the Advancement of

Educational Research (AAER) Ponte Vedra, FL. opinion papers retrieved from http://files.eric.ed.gov/fulltext/ED448205.pdf
Onwuegbuzie, A. J., & Combs, J. P. (2011). Data Analysis in Mixed Research: A Primer. *International Journal of Education, 3*(1), 125.
Onwuegbuzie, A. J., & Johnson, R. B. (2006). The Validity Issue in Mixed Research. *Research in the Schools, 13*(1), 48-63.
Pandey, V. P., Babel, M. S., Shrestha, S., & Kazama, F. (2011). A framework to assess adaptive capacity of the water resources system in Nepalese river basins. *Ecological Indicators, 11*(2), 480-488. doi:http://dx.doi.org/10.1016/j.ecolind.2010.07.003
Park, S., Howden, M., & Crimp, S. (2012). Informing regional level policy development and actions for increased adaptive capacity in rural livelihoods. *Environmental Science & Policy, 15*(1), 23-37. doi:http://dx.doi.org/10.1016/j.envsci.2011.09.004
Pelling, M., & High, C. (2005). Understanding adaptation: What can social capital offer assessments of adaptive capacity? *Global Environmental Change, 15*(4), 308-319. doi:http://dx.doi.org/10.1016/j.gloenvcha.2005.02.001
Perry, C. (1998). Processes of a case study methodology for postgraduate research in marketing. *European Journal of Marketing, 32*(9/10), 785-802. doi:doi:10.1108/03090569810232237
Perry, C. T., Kench, P. S., Smithers, S. G., Riegl, B., Yamano, H., & O'Leary, M. J. (2011). Implications of reef ecosystem change for the stability and maintenance of coral reef islands. *Global Change Biology, 17*(12), 3679-3696.
Pickett, S. T. A., Burch Jr, W. R., & Grove, J. M. (1999). Interdisciplinary Research: Maintaining the Constructive Impulse in a Culture of Criticism. *Ecosystems, 2*(4), 302-307. doi:10.1007/s100219900081
Pidgeon, N., Kasperson, R. E., & Slovic, P. (2003). *The social amplification of risk*: Cambridge University Press.
Plummer, R., & Armitage, D. (2010). Integrating Perspectives on Adaptive Capacity and Environmental Governance. In R. Plummer & D. Armitage (Eds.), *Adaptive Capacity and Environmental Governance* (pp. 1-19). Berlin: Springer-Verlag.
Pujadas, B. A., Garvin, T., & Szostak, R. (2013). Interdisciplinary Research for Ecosystem Management. *Ecosystems, 17*(3), 512-521. doi:10.1007/s10021-013-9737-1
Purdon, M. (2015). Advancing Comparative Climate Change Politics: Theory and Method. *Global Environmental Politics, 15*(3), 1-26. doi:10.1162/GLEP_e_00309
Rasheed, A. A. (2014). Historical institutionalism in the Maldives: A case of governance failure. *Maldives National Journal of Research, 2*(1), 7-28.
Renn, O., & Klinke, A. (2001). Environmental risks — perception, evaluation and management: Epilogue. In J. N. Gisela Böm, Timothy McDaniels, Hans Spada (Ed.), *Environmental Risks: Perception, Evaluation and Management (ed.) (Research in Social Problems and Public Policy, Volume 9)* (pp. 275-299): Emerald Group Publishing Limited.
Reser, J. P., Bradley, G., Glendon, A., Ellul, M. C., & Callaghan, R. (2012). *Public risk perceptions, understandings, and responses to climate change and natural disasters in Australia, 2010 and 2011*. Retrieved from Gold Coast: https://www.nccarf.edu.au/sites/default/files/attached_files_publications/Reser_2012_Public_risk_perceptions_Second_survey_report.pdf
Reser, J. P., & Swim, J. K. (2011). Adapting to and coping with the threat and impacts of climate change. *American Psychologist, 66 (4)*(May-June), 277-289. doi:http://dx.doi.org/10.1037/a0023412
Ritzer, G. (1990). Metatheorizing in Sociology. Sociological Forum, 5(1), 3-15. Retrieved from http://www.jstor.org.elibrary.jcu.edu.au/stable/684578
Robinson, S.-a. (2018). Climate Change Adaptation Limits in Small Island Developing States. In W. Leal Filho & J. Nalau (Eds.), *Limits to Climate Change Adaptation* (pp. 263-281). Cham: Springer International Publishing.
Romero-Frias, X. (1999). *The Maldive Islanders: a study of the popular culture of an ancient ocean kingdom*: Nova Ethnographia Indica.
Rosset, C. W. (1886). "The Máldive Islands: from Original Photographs." Graphic. *An Illustrated Weekly Newspaper*

Royle, S. A. (1989). A Human Geography of Islands. *Geography, 74*(2), 106-116. doi:10.2307/40571600

Royle, S. A. (2002). *Geography Of Islands*: Taylor & Francis.

Saeed, S. (2003). *Maldivian ways of knowing : an inquiry into cultural knowledge traditions and implications for schooling.* The University of British Columbia, [Vancouver, B.C.]. Available from http://worldcat.org /z-wcorg/ database.

Saloranta, T. (2001). Post-Normal Science and the Global Climate Change Issue. *Climatic Change, 50*(4), 395-404. doi:10.1023/A:1010636822581

Schlüter, M., Hinkel, J., Bots, P. W. G., & Arlinghaus, R. (2014). Application of the SES Framework for Model-based Analysis of the Dynamics of Social-Ecological Systems. *Ecology and Society, 19*(1). doi:10.5751/ES-05782-190136

Schwarz, A.-M., Béné, C., Bennett, G., Boso, D., Hilly, Z., Paul, C., . . . Andrew, N. (2011). Vulnerability and resilience of remote rural communities to shocks and global changes: Empirical analysis from Solomon Islands. *Global Environmental Change, 21*(3), 1128-1140. doi:https://doi.org/10.1016/j.gloenvcha.2011.04.011

Scobie, M. (2016). Policy coherence in climate governance in Caribbean Small Island Developing States. *Environmental Science & Policy, 58*, 16-28. doi:http://dx.doi.org/10.1016/j.envsci.2015.12.008

Selm, K. R., Hess, G. R., Peterson, M. N., Beck, S. M., & McHale, M. R. (2018). Developing an Instrument to Measure Autonomous Adaptive Capacity to Climate Change among Urban Households. *Frontiers in Ecology and Evolution*.

Shackleton, S., Ziervogel, G., Sallu, S., Gill, T., & Tschakert, P. (2015). Why is socially-just climate change adaptation in sub-Saharan Africa so challenging? A review of barriers identified from empirical cases. *Wiley Interdisciplinary Reviews: Climate Change, 6*(3), 321-344. doi:10.1002/wcc.335

Shafeeg, A. (2000). History of Malldives. *Dhanfulhi, 1,* 1-139.

Shaheed, A., & Upton, J. (2008). *Maldives: Reform Deferred? Challenges and Lost Opportunities for Democratic Transition* Paper presented at the 9th Annual Conference of Centre for the Study of Islam and Democracy, Washington DC.

Singh, P. K., & Nair, A. (2014). Livelihood vulnerability assessment to climate variability and change using fuzzy cognitive mapping approach. *Climatic Change, 127*(3), 475-491. doi:10.1007/s10584-014-1275-0

Sjöstedt, M., & Povitkina, M. (2017). Vulnerability of Small Island Developing States to Natural Disasters:How Much Difference Can Effective Governments Make? *The Journal of Environment & Development, 26*(1), 82-105. doi:10.1177/1070496516682339

Smit, B., & Pilifosova, O. (2003). From Adaptation to Adaptive Capacity and Vulnerability Reduction. In J. B. Smith, R. J. T. Klein, & S. Huq (Eds.), *Climate change, adaptive capacity and development*. London: Imperial College Press.

Smit, B., Pilifosova, O., McCarty, J. J., Canzianni, O. F., Leary, N. A., Dokken, D. J., & White, K. S. (2001). *Climate Change 2001: Impacts, Adaptation, and Vulnerability—Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (Vol. null).

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, 16*(3), 282-292. doi:10.1016/j.gloenvcha.2006.03.008

Smith, B., & Pilifosova, O. (2003). From Adaptation to Adaptive capacity and Vulnerability Reduction. In J. B. Smith, J. T. Richard, & S. Huq (Eds.), *Climate Change, Adaptive Capacity and Development* (pp. 356). London, GBR: Imperial College Press.

Smith, J. B., Vogel, J. M., & Ill, J. E. C. (2009). An architecture for government action on adaptation to climate change. An editorial comment. *Climatic Change, 95*(1), 53-61. doi:10.1007/s10584-009-9623-1

Smith, R.-A. (2018). Risk perception and adaptive responses to climate change and climatic variability in northeastern St. Vincent. *Journal of Environmental Studies and Sciences, 8*(1), 73-85. doi:10.1007/s13412-017-0456-3

South Asia Cooperation for Environment Programme. (2002). *Handbook on National Environmental Legislation and Institutions in the Maldives*. Retrieved from Colombo, Sri Lanka:

http://www.sacep.org/pdf/Reports-Technical/2001-UNEP-SACEP-Law-Handbook%20-Maldives.pdf

Sovacool, B. K. (2011). Hard and soft paths for climate change adaptation. *Climate Policy, 11*(4), 1177-1183. doi:10.1080/14693062.2011.579315

Sovacool, B. K. (2012). Expert views of climate change adaptation in the Maldives. *Climatic Change, 114*(2), 295-300. doi:10.1007/s10584-011-0392-2

Srinivasan, G., Jothiganesh, S., & Subbiah, A. R. (2012). *Development of a high resolution regional climate model: Climate change scenarios and their interpretation for the Maldives*. Retrieved from Maldives:

Steinberg, P. F. (2012). Welcome to the jungle: policy theory and political instability. In P. F. Steinberg & S. D. VanDeveer (Eds.), *Comparative environmental politics: theory practice and prospects* (pp. 255-284). Cambridge, Massachusetts, USA: MIT Press.

Stone, E. L., Jr.,. (1951). The soils of Axo Atoll, Marshall Islands. *Atoll Research Bulletin, 5*, 1-55.

Storlazzi, C. D., Gingerich, S. B., van Dongeren, A., Cheriton, O. M., Swarzenski, P. W., Quataert, E., . . . McCall, R. (2018). Most atolls will be uninhabitable by the mid-21st century because of sea-level rise exacerbating wave-driven flooding. *Science Advances, 4*(4). doi:10.1126/sciadv.aap9741

Stratford, E. (2008). Islandness and struggles over development: A Tasmanian case study. *Political Geography, 27*(2), 160-175.

Svedin, L. M. (2009). *Organisational Cooperation in Crises*. Farnham, UNITED KINGDOM: Taylor and Francis.

Swim, J. K., Stern, P. C., Doherty, T. J., Clayton, S., Reser, J. P., Weber, E. U., . . . Howard, G. S. (2011). Psychology's contributions to understanding and addressing global climate change. *American Psychologist, 66*(4), 241-250. doi:http://dx.doi.org/10.1037/a0023220

Szostak, R. (2013). Research skills for the Future: An interdisciplinary perspective. *Journal of Research Practice, 9*(1), 1-5.

Tanaka, K., & O'Neill, B. C. (2018). The Paris Agreement zero-emissions goal is not always consistent with the 1.5 °C and 2 °C temperature targets. *Nature Climate Change, 8*(4), 319-324. doi:10.1038/s41558-018-0097-x

Teddlie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research: integrating quantitative and qualitative approaches in the social and behavioral sciences*. Thousand Oaks: SAGE.

Television for Education Asia Pacific (Producer). (2009). Small Islands, Big Impact - featuring President Mohamed Nasheed of the Maldives. Retrieved from https://www.youtube.com/watch?v=10_RZl51-ko&feature=youtu.be

Thaman, K. H. (2003). Decolonizing Pacific studies: Indigenous perspectives, knowledge, and wisdom in higher education. *The Contemporary Pacific, 15*(1), 1-17.

Theodoridis, C. (2014). *A Phenomenological Case Study: Strategy Development in Small and Medium Retail Enterprises in Greece during Recession. SAGE Research Methods Cases. SAGE Publications, Ltd*. London, United Kingdom: SAGE Publications, Ltd.

Thomas, A., & Baptiste, A. K. (2017). Knowledge, perceptions, concerns, and behaviors to climate change—the Caribbean context: an introduction. *Journal of Environmental Studies and Sciences*. doi:10.1007/s13412-017-0462-5

Thomas, A., & Benjamin, L. (2017). Perceptions of climate change risk in The Bahamas. *Journal of Environmental Studies and Sciences*. doi:10.1007/s13412-017-0429-6

Thrift, N. (2008). *Non-representational theory: Space, politics, affect*. Abingdon, Oxon: Routledge.

Thywissen, K. (2006). *Components of risk: a comparative glossary*. Retrieved from Bonn: http://collections.unu.edu/view/UNU:1869#viewAttachments

Tol, R. S. J. (2015). Economic Impacts of Climate Change (Working Papers) (Publication no. https://www.sussex.ac.uk/webteam/gateway/file.php?name=wps-75-2015.pdf&site=24). (75-2015). Retrieved 6th January 2015, from University of Sussex

Tomczak, M., & Godfrey, J. S. (2003). *Regional Oceanography: An Introduction* (2nd ed.). Delhi: Daya Publishing House.

Toole, S., Klocker, N., & Head, L. (2015). Re-thinking climate change adaptation and capacities at the household scale. *Climatic Change, 135*(2), 203-209. doi:10.1007/s10584-015-1577-x

Transparency Maldives. (2015). *Climate finance governance in Maldives: Pressing issues, Position Paper*. Retrieved from Maldives: http://transparency.mv/2015/08/climate-finance-governance-in-maldives-pressing-issues/
Truelove, H. B., Carrico, A. R., & Thabrew, L. (2015). A socio-psychological model for analyzing climate change adaptation: A case study of Sri Lankan paddy farmers. *Global Environmental Change, 31*, 85-97. doi:http://dx.doi.org/10.1016/j.gloenvcha.2014.12.010
UN-Habitat. (2015). *Urbanisation and Climate Change in Small Island Developing States*. Retrieved from Nairobi, Kenya:
UNDP (United Nations Development Programme). (2008). *Detailed Island Risk Assessment in Maldives: Volume III: Detailed Island Reports: Th. Vilufushi – Part 1*. Retrieved from Maldives:
UNEP (United Nations Environment Programme). (1986). *Environmental problems of the marine and coastal area of Maldives: national report*. Retrieved from Nairobi, Kenya: http://www.ais.unwater.org/ais/aiscm/getprojectdoc.php?docid=4079
United Nations Environment Programme. (2005). *Maldives: Post-Tsunami Environmental Assessment.* Retrieved from UNEP Nairobi, Kenya: http://www.unep.org/tsunami/reports/maldives.pdf
United Nations Framework Convention on Climate Change. (1992). Full Text of The Convention: Article 1 Definitions.
Vannini, P. (2011). Constellations of ferry (im) mobility: islandness as the performance and politics of insulation and isolation. *Cultural Geographies, 18*(2), 249-271.
Vannini, P., & Taggart, J. (2013). Doing islandness: a non-representational approach to an island's sense of place. *Cultural Geographies, 20*(2), 225-242. doi:http://dx.doi.org/10.1177/1474474011428098
Vannini, P., Waskul, D., Gottschalk, S., & Ellis-Newstead, T. (2012). Making Sense of the Weather: Dwelling and Weathering on Canada's Rain Coast. *Space and Culture, 15*(4), 361-380. doi:10.1177/1206331211412269
VanWynsberghe, R., & Khan, S. (2007). Redefining case study. *International Journal of Qualitative Methods, 6*(2), 80-94.
Vedwan, N. (2006). Culture, Climate and the Environment: Local Knowledge and Perception of Climate Change among Apple Growers in Northwestern India. *Journal of Ecological Anthropology, 10*(1), 4-18. doi:http://dx.doi.org/10.5038/2162-4593.10.1.1
Vinton, C. C. (2010). *Cost Benefit Study of Disaster Risk Mitigation Measures in Three Islands in the Maldives*. Retrieved from Maldives:
Visam, M. (2016). Gaadhoo Islanders Anxiety, relocation to Fonadhoo by Force. *Raajjemv,* (7 January 2016). Retrieved from
Wadey, M., Brown, S., Nicholls, R. J., & Haigh, I. (2017). Coastal flooding in the Maldives: an assessment of historic events and their implications. *Natural Hazards, 89*(1), 131-159. doi:10.1007/s11069-017-2957-5
Walker, B. (2003) *The Resilience Alliance/Interviewer: E. Dyck*. IHDP news letter (Vol 02/2003), International Human Dimensions Programme on Global Environmental Change, Bonn, Germany.
Walker, B., Gunderson, L., Kinzig, A., Folke, C., Carpenter, S., & Schultz, L. (2006). A Handful of Heuristics and Some Propositions for Understanding Resilience in Social-Ecological Systems. *Ecology and Society, 11*(1).
Walker, B., & Meyers, J. A. (2004). Thresholds in ecological and social–ecological systems: a developing database. *Ecology and Society, 9*(2:3).
Wall, E., & Marzall, K. (2006). Adaptive capacity for climate change in Canadian rural communities. *Local Environment, 11*(4), 373-397. doi:10.1080/13549830600785506
Wang, S., Leviston, Z., Hurlstone, M., Lawrence, C., & Walker, I. (2018). Emotions predict policy support: Why it matters how people feel about climate change. *Global Environmental Change, 50*, 25-40. doi:https://doi.org/10.1016/j.gloenvcha.2018.03.002
Warrick, O., Aalbersberg, W., Dumaru, P., McNaught, R., & Teperman, K. (2017). The 'Pacific Adaptive Capacity Analysis Framework': guiding the assessment of adaptive capacity in Pacific island communities. *Regional Environmental Change, 17*(4), 1039-1051. doi:10.1007/s10113-016-1036-x

Watts, R. G. (2013). The Fifth Revolution. In R. G. Watts (Ed.), *Engineering Response to Climate Change* (pp. 1-43). Boca Raton: Taylor and Francis Group.

Werners, S. E., Pfenninger, S., van Slobbe, E., Haasnoot, M., Kwakkel, J. H., & Swart, R. J. (2013). Thresholds, tipping and turning points for sustainability under climate change. *Current Opinion in Environmental Sustainability, 5*(3), 334-340. doi:https://doi.org/10.1016/j.cosust.2013.06.005

Westley, F., Carpenter, S. R., Brock, W. A., Holling, C. S., & Gunderson, H. L. (2002). Linking theory to practice. In C. S. Holling & L. H. Gunderson (Eds.), *Panarchy: understanding transformations in human and natural systems* (pp. 103-119). Washington, DC: Island Press.

Williams, L. J., Afroz, S., Brown, P. R., Chialue, L., Grünbühel, C. M., Jakimow, T., . . . Roth, C. H. (2016). Household types as a tool to understand adaptive capacity: case studies from Cambodia, Lao PDR, Bangladesh and India. *Climate and Development, 8*(5), 423-434. doi:10.1080/17565529.2015.1085362

Williamson, T., Hesseln, H., & Johnston, M. (2012). Reprint of: Adaptive capacity deficits and adaptive capacity of economic systems in climate change vulnerability assessment. *Forest Policy and Economics, 24*(0), 48-54. doi:http://dx.doi.org/10.1016/j.forpol.2012.09.006

Wolf, J., & Moser, S. C. (2011). Individual understandings, perceptions, and engagement with climate change: insights from in-depth studies across the world. *Wiley Interdisciplinary Reviews: Climate Change, 2*(4), 547-569.

Woodroffe, C. D. (1993). *Morphology and Evolution of Reef Islands in the Maldives.* Paper presented at the 7th International Coral Reef Symposium, Guam.

Woodroffe, C. D., & Biribo, N. (2011). Atolls. In D. Hopley (Ed.), *Encyclopedia of Modern Coral Reefs: Structure, Form and Process* (pp. 51-71). Dordrecht: Springer Netherlands.

Work, R. (2002). *Overview of decentralisation worldwide: A stepping stone to improved governance and human development.* Paper presented at the Second International Conference on Decentralization,"Federalism: The Future of Decentralizing States, Manila, Philippines.

Wuebbles, D. J. (2013). Adapting to Climate Change. In R. G. Watts (Ed.), *Engineering response to climate change* (pp. 391-412). Boca Raton, FL: CRC Press.

Yarina, E., & Takemoto, S. (2017). Interrupted Atolls: Riskscapes and Edge Imaginaries in Tuvalu. *The Plan Journal, 2 (2),* 461-495. doi: 10.15274/tpj.2017.02.02.15

Yin, R. K. (2009). *Case study research: design and methods* (Vol. 4th). Thousand Oaks, Calif: Sage.

Yohe, G., & Tol, R. S. J. (2002). Indicators for social and economic coping capacity—moving toward a working definition of adaptive capacity. *Global Environmental Change, 12*(1), 25-40. doi:http://dx.doi.org/10.1016/S0959-3780(01)00026-7

Zahid. (2011). *The influence of Asian monsoon variability on precipitation patterns over the Maldives.* (PhD), University of Canterbury, Christchurch, New Zealand.

Appendix

A1: Focus group questionnaire

Focus Group: Session I

Theme 1- Island characteristics

Participants will in two groups do a participatory mapping of the island by doing a transect walk

☐ Visual identification of Key environmental features on a land use map and aerial photograph of the island

☐ Identify spatial features of the community/critical assets physical, social, financial

Focus Group: Session II

Theme 2- Weather extremes affecting the island community

Participants will in groups discuss

Show them the past 10 years climate data as a visual-

☐ Severe weather extremes experienced in the past 10 years and effects

(why is this a concern to you and how did it effect the island)

☐ List and rank the weather events according to impacts

☐ Give a chronological timeline of weather events

Focus Group: Session III

Theme 3 – Vulnerability to extreme weather events

Participants will in groups discuss

☐ Spatial vulnerability and why some areas of the island are vulnerable

☐ Will discuss vulnerability of assets to climate stimuli such as physical, financial, human social and natural assets

☐ Will develop causal flow maps to indicate causes and consequences of asset vulnerabilities and extent to which vulnerability is related to climatic stimuli

Causes>>>>>> Asset vulnerability>>>>>>> Consequences

☐ Discuss correlations of weather events to employment, education etc. and how certain assets of livelihood capitals are affected

☐ Will discuss how social capital relate to vulnerability of community

Sources: human activities that introduce stress to environment

Stressors: direct causes of impact

Impacts: based on personal values what impacts are being felt

Focus Group Session IV

Theme 4 – Adaptation strategies and actions and assets enhancing resilience

Participants will in groups discuss

☐ List and rank the assets which enhance adaptation to different climate stimuli focusing on how each asset is utilised before, during and after events

☐ List adaptive strategies and actions undertaken by households and community before, during and after impacts

☐ Use a problem tree and solution tree to discuss how weather-related vulnerabilities can be addressed

☐ Discuss the causes and solutions for impacts due to different climate stimuli using causal flow diagrams (e.g. Disease outbreak caused by severe rain and solutions)

Focus Group Session V

Theme 5 – Institutional capacity in coping and adjusting to climatic stimuli

Participants will in groups discuss

☐ List and rank local institutions and their importance to cope and adjust with climate stimuli

☐ Map spatial locations of institutions, their importance and how they contribute to cope and adjust with climate stimuli

☐ Map the interconnections of different institutions before, during and after events

☐ Identify the effectiveness of public institutions, NGOs and CBOs in helping the community to cope and adjust with the climatic stimuli

A2: Key informants interview questionnaire

1- How much of your organisation's work involve formulation of climate change adaptation policy and strategies?
2- Can you brief some specific climate change adaptation related projects undertaken by your organisation (NGO) in the last five years? Who funds these projects?
3- What is the goal of these projects?
4- Are these projects undertaken based on wider public consultation? How are decisions made?
5- Please brief about the effectiveness of these projects? Did the project achieve the set goals and targets!?
6- If not effective, why do you think they are not effective?
7- Are you aware of government policies, strategies and actions to enhance adaptation to climate change? Are people aware of the most effective adaptation measures of climate change!?? Design aspects etc!
8- Do you think the policies, strategies and actions in place are effective for future adaptation of islands?
9- Which elements of these existing adaptation policies/strategies and actions are effective and socially viable?
10- What is your opinion on the leadership role of the government in climate change, both locally and internationally? Can you elaborate more on the change in leadership from the time you started working in the field till now?
11- Do you wish to share any more information based on your experience, regarding climate change adaptation in the Maldives?
12- How can the government develop more efficient adaptation policies and programs?
13- Do you believe climate change policies are an election issue! An issue of political significance?

A3: Household survey questionnaire

Assessment of awareness regarding the households' vulnerability of social and economic conditions due to the effects of climate change

1 Form Identification number [...] [...] [...] [...] [...]

2 Island Name ---

3 Enumerator Code [.......]

4 House Location

☐ Less than 50 metres from shoreline

☐ Between 50- 100 metres from shoreline

☐ More than 100 metres from shoreline

5 Household condition

☐ House fully built (Complete)

☐ House partially built (Incomplete)

☐ Temporary housing

6 Interview Date:______ /______ / 2015 Time started _______ Time finished ______

7 Did household head complete the survey?

☐ Yes ☐No

8 List questions not answered or questions the respondent don't want to answer:

----

9 Survey proceedings checked by

Name: ---

Signature: ---

SECTION 1: General background information of households

1- Head of household
   Age: _____
   Gender: _____
2- Number of years in school ------
3- Employment status

   Employed in -----------------------------

   ☐ Unemployed/looking for work

   ☐ Retired

   ☐ Housewife

4- Were you born in this island?

   ☐ Yes ☐ No *(go to Question 5)*

5- Birth island ---
6- Purpose of migrating to this island --------------------------------------

SECTION 2: Demographic characteristics of household

7- Number of people living in your household

   ☐ Children below 18 years _____

   ☐ Adults above 18 years _____

   ☐ Relatives other than your immediate family ______

   ☐ Visitors or guests ______

   ☐ Tenants on rent ______

8- Educational qualifications of the members living in the household

   ----------- Members have completed or is completing university education

   -------------Members have completed or is completing higher secondary education

   -------------Members have completed or is completing lower secondary education

   -------------Members have completed or is completing primary education

   -------------Members have completed or is completing vocational education and training

9- How many family members of you live outside the island? What is their purpose and to which islands have they moved to

☐ For education, moved to ______________________________

☐ For health reasons, moved to __________________________

☐ For employment, moved to ____________________________

☐ For marital reasons, moved to __________________________

☐ Any others (*please specify*) _____________________________

10- How often does your family members outside the island visit you?

☐ more than once a year ☐ once a year ☐ rarely

11- Do you or your family own this house? (*if not, are you renting and what's the rent per month*)

☐ Yes ☐ No

If no, what is your rent per month? MVR ___________

12- Is your house size adequate for your family?

☐ Yes ☐ No

SECTION 3: Socio Economic Characteristics of households

13- Household monthly income:

Income source (please tick)		Income range (in MVR)	Does this income change with changes in extreme weather? Please specify the weather extreme
Wages			
Old age pension			
Remittances			
Own business			
Fish/agricultural products/ etc.			
*			

**any other sources of income please specify*

14- Monthly average income (for instance, an amount between MVR 3,000 – 5,000)

____

15- Are you paying for any loans?

☐Yes ☐No

16- For what purpose did you take the loan? ____
____

17- Have you changed your main income earning activity during the past 5 years?

☐Yes ☐No

18- If it was not voluntary, please give a reason for this change? ___________________________
____

19- Please specify average monthly expenditure (in MVR) for

☐ Food_________ ☐ Education___________ ☐ Electricity & gas _________

☐ Transport_________ ☐ Others________

20- What is your average monthly expenditure? (for instance, an amount between MVR 3,000 – 5,000)

____

21- How does your standard of living in the island compare to others in the island? Please tick.

☐ Lower class ☐ Middle class ☐ Upper middle class ☐ Upper class

22- From the items given in the list below, please circle all items in your household with number of each item

Fridge	Mixer, Blender	Gas Stove	Radio	TV set	Computer	Laptop

iPad	Washing machine	Sewing Machine	Air conditioner	Boat	Motor Cycle

Water tank	Water pump	Flushing toilet	Fans	Push Bike	Generator set

Fishing gear	Farming gear	Microwave Oven	Vacuum cleaner	Rice cooker	Telephones Mobile phones	Cable TV

Any others please specify--

SECTION 4: Social affiliation and bonding and networking

23- This table is about your perceptions on your affiliation with community and social bonding. Rate the following statements from a scale of 1 to 5 by ticking the appropriate box ☑ From 1 being the lowest and 5 being the highest.

	Strongly agree			Strongly disagree	
	5	4	3	2	1
I can rely on my relatives and friends when I need their help	☐	☐	☐	☐	☐
I take part in communal activities (such as during Eid festival or discussions on important issues in the island)	☐	☐	☐	☐	☐
I provide financial and various other support to friends and relatives when they are in need	☐	☐	☐	☐	☐

24- Number of household members belonging to a community organisation or a cooperative society ☐☐

25- Do members of your household take part in voluntary activities conducted in the island?
☐ Yes ☐ No

26- If yes, do you think participation is good --

27- Do you watch or listen to news (and other media) programs on a regular basis?
☐ Yes ☐ No

28- Do you get information regarding climate change through media (radio, TV, newspaper, magazines) to a satisfactory level?

☐ Highly Satisfactory ☐ Moderately sufficient ☐ Don't receive at all

SECTION 5: Difficulties faced by households due to natural disasters

29- Have you experienced any difficulties in the past 10 years as a result of climate change related events that impacted your household?

☐ Yes ☐ No

30- If yes, did it affect?

☐ Property ☐ Health ☐ Livelihood ☐ Life of someone (death)

☐ Other (please specify) ________________________________

31- Which of these difficulties have you experienced in your island over the past 10 years due to climate change? (please tick as appropriate)

☐ Swell waves ☐ Rainfall flooding ☐ Strong winds ☐ Beach erosion

☐ Heatwaves ☐ Drought

Any others (please specify) ____

32- Which of the above had the most impact to your household and why?

____

____

33- Did your household cope and adjust with these impacts?

☐ Yes ☐ No (give reason)

Reason: ____

34- Do you believe that the frequency of these impacts has changed recently?

☐ Highly increased ☐ Increased ☐ Reduced ☐ No change at all

35- Has a member of your household faced any health problems as a result of climate change effects?

☐ Yes ☐ No

36- If yes, which health problems are more prevalent:

____

37- Do you believe your household's physical infrastructure is strong enough to withstand the impacts?

☐ Yes ☐ No

If no, please specify reasons? ____

38- What strategies or actions will you take to cope and adjust with the effects of climate change, if these impacts become more severe or prevalent in the future?

☐ Relocate the house to a different part of island

☐ Renovate and modify the house to accelerating conditions

☐ Change livelihood (*If so, to what alternative livelihood)* ___________________________

☐ Migrate to another island (Please name the island of your choice) __________________

39- What influences your household's capacity to cope with the impacts from climate change better? Can you please rank them from 1-5 with one being the most influential factor?

	Rank
☐ Money	☐
☐ Shelter or a place to live	☐
☐ Good relationship with extended family and neighbours	☐
☐ Government aid and assistance	☐
☐ Loan aid	☐
☐ Other (please specify) ___________________________________	

The end

A4: Informed consent form

PRINCIPAL INVESTIGATOR: Ibrahim Mohamed
PROJECT TITLE: Adaptive Capacity of Islands of the Maldives to Climate Change
COLLEGE: College of Marine and Environmental Sciences.

I understand the aim of this research study is to explore the strategies, actions and mechanisms utilised by our island community to cope with climate change impacts. I consent to participate in this project, the details of which have been explained to me, and I have been provided with a written information sheet to keep.

I understand that my participation will involve an interview, a questionnaire survey, and focus group participatory activities, and I agree that the researcher may use the results as described in the information sheet.

I understand that focus group participatory activities conducted with members of my community, regarding the strategies, actions and mechanisms utilised in the community to cope with impacts of climate change, will be conducted as workshops in 4 sessions each of which will be approximately an hour.

I acknowledge that:

- Taking part in this study is voluntary and I am aware that I can stop taking part in it at any time without explanation or prejudice and can withdraw any unprocessed data I have provided;
- That any information I give will be kept strictly confidential and that no names will be used to identify me with this study without my approval;
- Confidentiality cannot be assured in focus groups.

(Please tick to indicate consent)

I consent to be interviewed		**Yes**		**No**
I consent for the interview to be audio taped		**Yes**		**No**
I consent to complete a questionnaire		**Yes**		**No**
I consent to participate in a focus group activity to be audiotaped and videotaped		**Yes**		**No**

Name:	
Signature:	**Date:**

A5: Information sheet for participants

PROJECT TITLE: Adaptive Capacity of Islands of the Maldives to Climate Change

You are invited to take part in a research project to explore the ability of islands of the Maldives to: adjust to and moderate potential climate impacts and risks and to utilise opportunities available to cope with consequences. The research will provide understanding of the potential for and limits to climate change adaptive capacity in the islands of the Maldives. The study is being conducted by Ibrahim Mohamed and will contribute to a PhD on Environmental Science and Management at James Cook University, Australia.

The invitation to take part will be sent to you by your island council and you have the right to decline the invitation. If you agree to be involved in the study, you will be given a survey questionnaire and/or interviewed and/or asked to take part in a focus group participatory activity with members of your community, regarding the strategies, actions and mechanisms utilised in the community to cope with impacts of climate change. The questionnaire survey will take about 35-45 minutes and the interview will take 40-50 minutes. The interview, with your consent, will be audio-taped and focus group activities will be videotaped and audiotaped with your consent. Focus group participatory activities will be conducted similar to workshops in 4 different sessions each of which will be approximately an hour. The interview will be conducted at a venue of your choice.

Taking part in this study is completely voluntary and you can stop taking part in the study at any time without explanation or prejudice.

Please be informed that there are no risks or distress involved in taking part in this research. The information you provide will be utilised for academic purposes only.

Your responses and contact details will be strictly confidential. The data from the study will be used in research publications and reports and conference presentations as well as in the research thesis. You will not be identified in any way in these publications. However, your institutions or organisations will be named with permission.

If you have any questions about the study, please contact:

Principal Investigator:
Ibrahim Mohamed
College of Marine and Environmental Sciences
James Cook University
Email: ibrahim.mohamed@my.jcu.edu.au

Supervisor:
Associate Professor David King
College of Marine and Environmental Sciences
James Cook University
Phone: +61 7 478 14430
Email: david.king@jcu.edu.au

If you have any concerns regarding the ethical conduct of the study, please contact:
Human Ethics, Research Office
James Cook University, Townsville, Qld, 4811
Phone: (07) 4781 5011 (ethics@jcu.edu.au)