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EMPIRICAL ANALYSES OF MIGRATION IN SMALL ISLANDS: THE ROLE OF ENVIRONMENTAL AND SOCIAL FACTORS

by

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ABSTRACT

Low-lying atoll islands are highly threatened by anticipated sea-level rise, and migration is often mentioned as a potential response of island residents to this challenge. However, understanding of contemporary migration processes in small island settings is limited. This thesis analyses contemporary and potential future migration in small island settings, using the atoll nation of the Maldives as a case study. It asks four research questions: (1) What is known about present migration in small island settings to provide an empirical foundation for migration studies, including the potential role of climate change?; (2) What are contemporary drivers and indicators of migration flows in small islands?; (3) What are contemporary migration decision-making processes in small islands, including the role of the environment?; and (4) What are plausible future demographic and migration pathways for small islands? These research questions are answered using a systematic literature review, analysis of census and environmental vulnerability datasets, a survey conducted in 2015, and an agent-based model of migration using this data, respectively.

The results are as follows. Important drivers of migration in small island settings include professional opportunities, size of migration networks, population policies and pressure, and quality of living environment. Migration within the Maldives has been a significant process over the last few decades with the heavily urbanised capital area 'Greater Malé' growing at the expense of the other islands. This has resulted in a strong dichotomy between professional opportunities, health services, and quality of life between Greater Malé and other islands. An important result is a high *potential* for international migration from the Maldives, which is not presently being realised. Both internal and international migration intentions of Maldivians are mainly driven by perceived professional opportunities. Historic climate change has not influenced migration to date. Further, internal or international migration *in anticipation of* climate change is not apparent from the data collected, and seems unlikely unless conditions change significantly. A significant population increase is projected for Greater Malé for all development scenarios up to 2050. The highest migration flows occur under a scenario with high population growth, high impacts of climate change, international migration, and low government involvement.

Hence, today's migration is due to multiple non-environmental factors. To understand the direct impacts of environmental change on migration considerations, its interaction with non-climate drivers of migration must be understood. Successful population and adaptation policy, such as land reclamation and raising islands, need to consider migration dynamics, employment, education, and other services. In the Maldives, and other small islands, this requires an integrated and nation-wide view of development and adaptation.

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DECLARATION OF AUTHORSHIP

I, Laurens Speelman

declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

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I confirm that:

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Chapter 3-6 present substantial, self-contained, complementary research in the format of scientific publications and are based on submissions to academic journals. The description below establishes the candidate's contribution to the published papers.

Chapter 3: *Speelman, L.H.,* R.J. Nicholls, J. Dyke (submitted) Present migration drivers and the potential role of climate change in small island settings

L. H. Speelman was involved in all aspects of the work and was responsible for conception, design, analysis and interpretation of data, and drafted the manuscript. Prof. dr. R.J. Nicholls has been involved in the conception, design, analysis and interpretation of data and provided critical comments and revisions. Dr. J. Dyke J provided critical comments and revisions.

Chapter 4: *Speelman, L.H.,* R.J. Nicholls (submitted) Migration flows in a small island setting: a case study of the Maldives and its wider implications

L. H. Speelman was involved in all aspects of the work and was responsible for conception, design, analysis and interpretation of data, and drafted the manuscript. Prof. dr. R.J. Nicholls has been involved in the conception, design, analysis and interpretation of data and provided critical comments and revisions.

Chapter 5: *Speelman, L.H.*, R.J. Nicholls, J. Dyke (submitted) Contemporary migration intentions in the Maldives: The role of environmental and other factors

L. H. Speelman was involved in all aspects of the work and was responsible for conception, design, analysis and interpretation of data, and drafted the manuscript. Prof. dr. R.J. Nicholls has been involved in the conception, design, analysis and interpretation of data and provided critical comments and revisions. Dr. J. Dyke J provided critical comments and revisions.

Chapter 6: *Speelman, L.H.*, R.J. Nicholls, J. Dyke (submitted) Simulating migration in the Maldives: Exploring future pathways

L. H. Speelman was involved in all aspects of the work and was responsible for conception, design, analysis and interpretation of data, and drafted the manuscript. Prof. dr. R.J. Nicholls has been involved in the conception, design, analysis and interpretation of data and provided critical comments and revisions. Dr. J. Dyke J provided critical comments and revisions drawing on his experience of agent-based models.

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Abbreviations

AA	Affective Attitude
ABM	Agent-Based Model
AR4	Fourth Assessment Report of the IPCC
AR5	Fifth Assessment Report of the IPCC
AOSIS	Alliance of Small Island States
BF	Background Factors
CMM	Conceptual Model of Migration
COP	Conference of Parties (to the UNFCCC)
DESA	Department of Economic and Social Affairs (of the United Nations)
EA	Environmental Attitude
FAR	First Assessment Report of the IPCC
GDP	Gross Domestic Product
IA	Instrumental Attitude
INT	Intention
IPCC	Intergovernmental Panel on Climate Change
MARC	Migration Adaptation to Rainfall Change
NAPA	National Adaptation Plan of Action
PBC	Perceived Behavioural Control
RCP	Representative Concentration Pathways
SIDS	Small Island Developing States
SN	Social Norms
SRES	Special Report on Emission Scenarios

UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VPA	Vulnerability and Poverty Assessment

Chapter 1 Introduction

The first papers and Intergovernmental Panel on Climate Change (IPCC) report on climate change and its impacts on small islands in the early 1990s already recognised that sea-level rise could lead to serious impacts in small island states, especially low-lying atoll islands where total inundation was feasible (Lewis, 1990b; Pernetta and Sestini, 1989; Pernetta, 1992; Tegart et al., 1990). The potential impacts of climate change to small island states are now well established (Nurse et al., 2014). Related climate drivers include sea-level rise, storms, increasing air and sea surface temperatures, ocean acidification, and changing rainfall patterns. These are in turn likely to impact the ecosystems on which people living on small islands depend, including coastal erosion and inundation, salinisation of fresh water lenses, coral bleaching, changing abundance and distribution of fish species, and agriculture. Further impacts on various key economic sectors such as tourism and ports/shipping could be significant.

Global analyses suggest that island regions will experience the largest relative increase in flood risk due to sea-level rise in the coming century (Nicholls et al., 1999; Nicholls, 2004), and low-lying atoll regions appear to be consistently vulnerable across a wide range of scenarios (Nicholls and Tol, 2006).

These studies all reinforced the high vulnerability of small island states and especially low-lying atoll islands. This vulnerability is further enhanced as many of the small island states have limited resources and are ill-equipped to deal with existing environmental problems and issues such as large population growth, overdevelopment, and pollution (Leatherman and Beller-Sims, 1997). Further, the characteristics of small island states present many difficulties for sustainable development (Maul, 1996).

The high vulnerability to climate change, and sea-level rise in particular, of small island states has resulted in expectations that increased permanent migration and island abandonment will be the ultimate consequence. The first papers and IPCC report already mentioned migration and ecological refugees as the major potential impact of climate change for small island states (Lewis, 1990b; Pernetta and Sestini, 1989; Pernetta, 1992; Tegart et al., 1990). This view has been reiterated in all subsequent IPCC reports (Bijlsma et al., 1996; McCarthy et al., 2001; Mimura et al., 2007; Nurse et al., 2014; Watson et al., 1997; Zinyowera et al., 1995). More recently, the potential high costs of adapting on islands was linked to a need for migration (Biermann and Boas, 2010; Gemenne, 2011; Nicholls et al., 2011). The potential abandonment of entire nations has sparked discussion on the role of small island states in international law, human rights, and has made the small island states a key issue in the climate change debate.

Since the First Assessment Report (FAR) of the IPCC in 1990, many studies linking migration to climate change *directly* projected physical changes on coastal societies and much of the debate focuses on an assumed link between migration and climate change. However, identifying a causal relationship has lacked empirical investigation, to date. Migration is a complex process and it is too simplistic to attribute changing migration flows solely to environmental or climate induced factors. On the contrary, migration scholars traditionally focus on socio-economic, cultural and political factors. Only in recent years it has been acknowledged that linkages are complex and operate through a large variety of drivers (e.g. Black et al., 2011a). Understanding present and future migration flows, including the role of the environment, requires an interdisciplinary approach, focusing on environmental and socio-economic drivers, and individual cognition of the residents. Such empirical research is widely lacking and requires advances in empirical migration research. Such advances depend on increased collection of quantitative data; adoption of sophisticated statistical modelling approaches; and greater collaboration between environmental and migration researchers (Fussel et al., 2014).

1.1 Research aim and questions

This thesis contributes to this research gap and provides detailed empirical analyses of migration processes and behaviour in small islands. It analyses present migration and defines potential future (migration) pathways. This sets the impacts of climate change on migration in context, and allows better-informed adaptation and population policies.

The aim of this thesis is to analyse contemporary and potential future migration in small island settings.

This is accomplished by answering the following research questions:

1. What is known about present migration in small island settings to provide an empirical foundation for migration studies, including the potential role of climate change?
2. What are contemporary drivers and indicators of migration flows in small islands?
3. What are contemporary migration decision-making processes in small islands, including the role of the environment?
4. What are plausible future demographic and migration pathways for small islands?

To allow detailed investigation of these questions, the Maldives is analysed as a representative case study of a small island atoll state. These results are contrasted with other published results, especially for the Pacific atoll nations, to define their global implications.

1.2 Structure

Chapter 2 provides a theoretical background to this study, introducing concepts of environmental change and its links to migration, and theories of migration. **Chapter 3 to Chapter 6** present independent, complementary research in the format of stand-alone scientific publications, each answering a research question as formulated in section 1.1. More specifically, **Chapter 3** provides an overview of the determinants of migration in small island settings based on a systematic review. **Chapter 4** explores migration behaviour between islands in one island nation -- the Republic of Maldives from 1985 to 2006, based on demographic, socio-economic, and environmental datasets. **Chapter 5** builds on the results presented in Chapter 4 and presents a detailed description of migration processes important in a small island setting based on quantitative questionnaires completed in the Maldives during 2015. **Chapter 6** explores the implications of the processes identified in the previous chapters. An agent-based model is developed and used to simulate demographic change in a small island setting up to 2050. Interactions between demographic, environmental, policy, and international migration scenarios are discussed. **Chapter 7** summarises the main conclusions of this thesis and places the findings in a broader perspective. Policy recommendations and recommendations for further work are presented.

Chapter 2 Theoretical background: Migration and environmental change

This chapter provides the theoretical background to this thesis. Climate change and sea-level rise have been linked to an increase in migration and environmental refugees. This link is explored and discussed within the context of vulnerability of small island states to climate change impacts. To understand migration processes, including its links to environmental change, classic migration theories and recent advances in linking environmental change and migration are discussed. The Maldives is introduced as a case study to allow detailed empirical investigation in the thesis. Lastly, an overview of the remaining chapters is provided.

2.1 Climate change, small island states, and migration: general concepts

This section introduces the *environmental science* dimension to linking migration to environmental change and discusses general concepts of climate change and vulnerability of coastal societies and small island states in particular. The theoretical links with migration flows and behaviour and island abandonment are then further introduced.

2.1.1 Climate change and sea-level rise

Climate is usually defined in terms of the mean and variability of relevant quantities over a period of 30 years. Climate includes variables such as temperature, precipitation and wind, but also the associated statistics (frequency, magnitude, persistence, trends, etc.), often combining parameters to describe phenomena such as droughts (Cubasch et al., 2014). Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (Cubasch et al., 2014).

Climate change is caused by changes in the radiative balance between incoming solar shortwave radiation and outgoing longwave radiation (see Figure 2.1). Natural fluctuations in solar output (solar cycles) can cause changes in the energy balance by changes in incoming short wave radiation. Human activity and volcanic eruptions changes the emissions of gases and aerosols, which are involved in atmospheric chemical reactions. These reactions result in modified O_3 and aerosol amounts. These particles directly influence the radiative balance. Examples of aerosols include particles that influence the formation of clouds. As there are large interactions between clouds and short- and long wave radiation, changes in the properties of clouds can have a large

impact. Further, anthropogenic changes in greenhouse gases and emission of large aerosols modify the amount of outgoing long-wave radiation. Surface albedo is influenced by changes in vegetation or land surface properties (for example due to changes in land use), snow or ice cover and ocean colour (Cubasch et al., 2014).

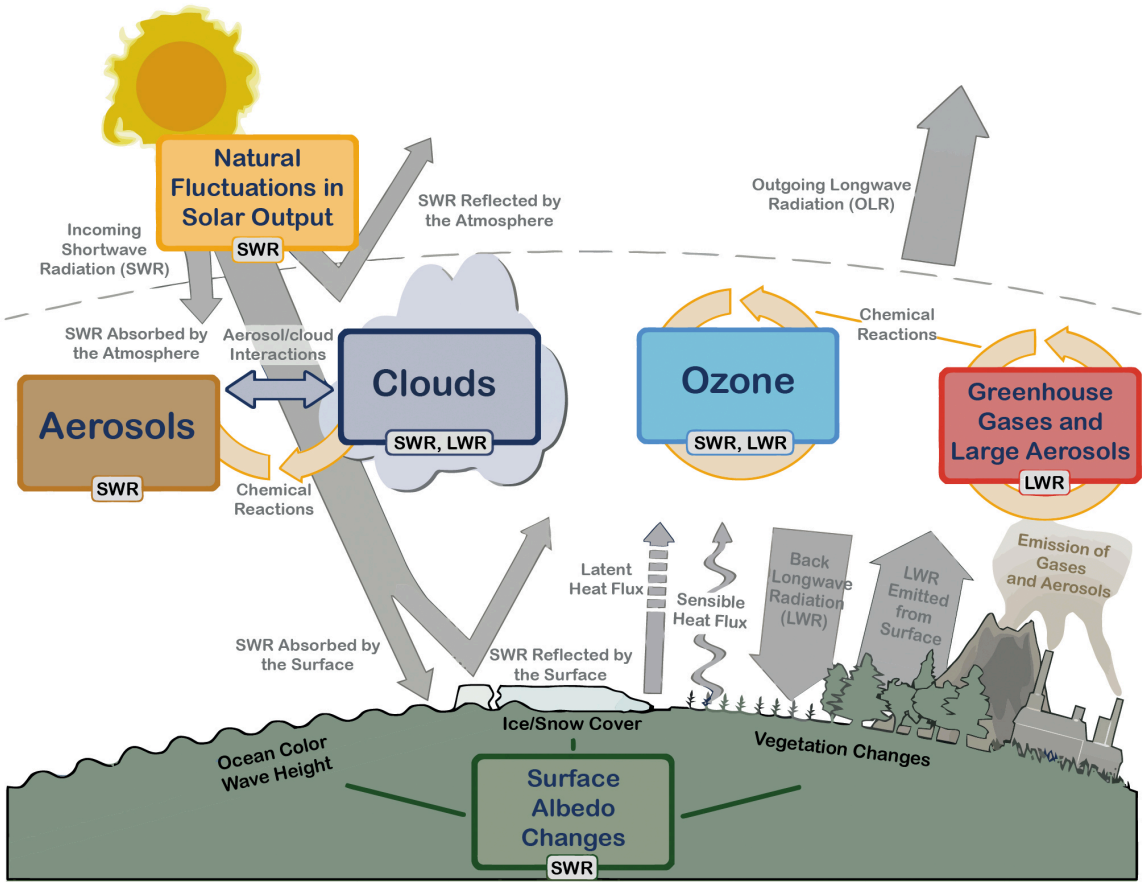

Figure 2.1 Main drivers of climate change (Cubasch et al., 2014).

The total radiative forcing is currently positive, and this has led to an increase of energy in the climate system. The largest contribution is the increase of atmospheric CO_2 since 1750, which can largely be attributed to anthropogenic change (Stocker et al., 2014). The global mean surface temperature has increased since the late 19th century and there have been changes in the energy budget, circulation, water cycle, sea level, climate extremes, and biogeochemical (CO_2) cycles (Stocker et al., 2014). These changes are expected to continue in the future. The global mean surface temperature rise for the period 2016–2035 relative to 1986–2005 will likely be in the range of 0.3°C to 0.7°C (Stocker et al., 2014). Depending on the representative concentration pathways (RCP) to describe the range of possible futures for radiative forcing developed by the IPCC, global mean temperature for 2081–2100 will gradually increase with 0.3°C to 1.7°C (RCP2.6),

1.1°C to 2.6°C (RCP4.5), 1.4°C to 3.1°C (RCP6.0), 2.6°C to 4.8°C (RCP8.5) as compared to the period 1986-2005 (Stocker et al., 2014).

The rate of global mean sea-level rise has increased from a few centimetres per century to a few decimetres per century in the past centuries (Jevrejeva et al., 2008; Church and White, 2011; Ray and Douglas, 2011). This increase can be attributed to climate change and its related processes of thermal expansion of ocean water, melting of land-based ice, and changes in surface water storage (Church et al., 2013). The Fifth Assessment Report (AR5) of the IPCC estimates sea-level to rise for the period 2081–2100, compared to 1986–2005, between 0.26 to 0.55 m for RCP2.6, 0.32 to 0.63 m for RCP4.5, 0.33 to 0.63 m for RCP6.0, and 0.45 to 0.82 m for RCP8.5.

Ice dynamics are identified as a large source of uncertainty in sea-level rise projections and the models used by the IPCC can only explain about 60% of observed sea-level trends. Therefore, the ranges provided by the IPCC are often considered to be conservative estimates (e.g. Pfeffer et al., 2008; Rahmstorf, 2007). Providing these upper bounds beyond the conventional range of the IPCC is especially valuable for coastal management and adaptation to sea-level rise (Nicholls et al., 2014; Hinkel et al., 2015). This has motivated the development of semi-empirical models of sea-level rise. Such semi-empirical approach regards a change in sea level as an integrated response of the entire climate system, in contrast to its separate physical components (Church et al., 2013). Estimates of sea-level rise based on such approach often yield higher estimates and higher uncertainties of sea-level rise. For example, estimates of sea-level rise for 2081–2100, compared to 1986–2005, for RCP4.5 by Rahmstorf (2012) are between 0.56 m and 1.24 m and 0.57 m and 0.68 m, depending on the dataset used for calibration. Various other approaches showed that a multi-meter increase in sea-level in 2100 cannot be ruled out and include estimates up to 1.90 m (Rahmstorf et al., 2012), 2.0 m (Pfeffer et al., 2008), 2.25 m (Sriver et al., 2012), and 2.4 m (Nicholls et al., 2011).

Impacts of climate change and sea-level rise relevant to migration processes can be broadly divided into rapid onset impacts and slow onset impacts. Examples of rapid onset impacts of climate change include climate-related extremes, such as heat waves, droughts, floods, cyclones, and wildfires. Examples of slow onset impacts include impacts on agricultural production and food security, fisheries, fresh water availability, changes in forestry, and increased soil erosion (Field et al., 2014).

Studies looking at impacts of climate change in deltas and small island states mainly focus on the effects of sea-level rise, erosion, and flooding. For example, Ericson et al. (2006) estimated rates of effective sea-level rise for a sample of 40 deltas worldwide. Effective sea-level rise is a net rate, including eustatic sea-level rise, the natural gross rate of fluvial sediment deposition and

subsidence, and accelerated subsidence due to groundwater and hydrocarbon extraction. Low-lying areas near river deltas and estuaries are vulnerable to sea-level rise, and this poses risks to vulnerable communities in, for example, the lower Mekong River Basin (e.g. Hijioka, 2014) and could impact food production in deltaic areas in Bangladesh, Vietnam, and Myanmar (e.g. Dasgupta, 2008; Wassmann et al., 2009).

2.1.2 Environmental refugees and climate change

Research about climate change-induced migration builds on discussions about environmental refugees. The term 'environmental refugee' was first coined by Lester Brown of the Worldwatch Institute in the 1970s (Saunders, 2000) and was brought into the public debate by Essam El-Hinnawi in 1985 (Jacobson 1988). Myers (1993) defined environmental refugees as 'people who can no longer gain a secure livelihood in their erstwhile homelands because of drought, soil erosion, desertification, and other environmental problems' .

There are no robust estimates of future displacement and migration. Most notably, Myers and Kent (1995) and Myers (1993, 1997, 2002) have attempted to estimate the number of future environmental refugees. For example, Myers (2002) estimated that there were already 25 million environmental refugees as of 1995. Further, Myers (2002) estimated, based on population growth in vulnerable regions, that there could be as many as 200 million environmental refugees in 2050 due to sea-level rise and coastal flooding, changing precipitation patterns, and droughts of unprecedented severity and duration. However, both the definition and estimates of Myers have been criticised (e.g. Adger et al., 2014; Barnett and O'Neill, 2012; Black, 2001; Suhrke, 1993, 1994). Black (2001) provides direct criticism to the estimates of Myers and others and argues that the term 'environmental refugee' is very poorly defined and that estimates of environmental refugees are based on evidence that is far from convincing. Further, the estimates of Myers are criticised as they fail to capture the reality of climate change impacts, the capacity to adapt, and the actual drivers of migration (Barnett and O'Neill, 2012).

People have historically left places with harsh or deteriorating conditions, whether this is in terms of poor rainfall, high unemployment, or political upheaval, or some combination of these or other adverse factors (e.g. Black, 2001; Black et al., 2011a).

There have been increasing efforts to empirically link changes in the environment to migration, most notably in areas where daily livelihoods depend on the local environment (e.g. Henry et al., 2003; Henry et al., 2004; Hunter et al., 2014). Studies focused on the effect of, for example, droughts and precipitation and soil degradation (Afifi, 2011; Doevenspeck, 2011; Ezra and Kiros, 2001; Findley, 1994; van der Geest, 2011) or of extreme events (Dun, 2011; Myers et al., 2008;

Stal, 2011). In the past, extreme weather events have led to significant (temporary) population displacement, and changes in the frequency of extreme events will amplify the risks and impacts of such displacement. Extreme weather events are the most direct pathway from climate change to migration (Adger et al., 2014). Such cases can often not be directly attributed to climate change, but increased frequency and intensity of drought events and precipitation are expected as a result of climate change, potentially leading to similar patterns of migration.

2.1.3 The vulnerability of small island states to climate change

Global analyses suggest that island regions will experience the largest relative increase in flood risk due to sea-level rise in the coming century (Nicholls et al., 1999; Nicholls, 2004), and low-lying atoll regions appear to be consistently vulnerable across a wide range of scenarios (Nicholls and Tol, 2006). Due to their high vulnerability, small island states have been consistently linked to migration since the FAR of the IPCC (Bijlsma et al., 1996; McCarthy et al., 2001; Mimura et al., 2007; Nurse et al., 2014; Tegart et al., 1990; Watson et al., 1997; Zinyowera et al., 1995).

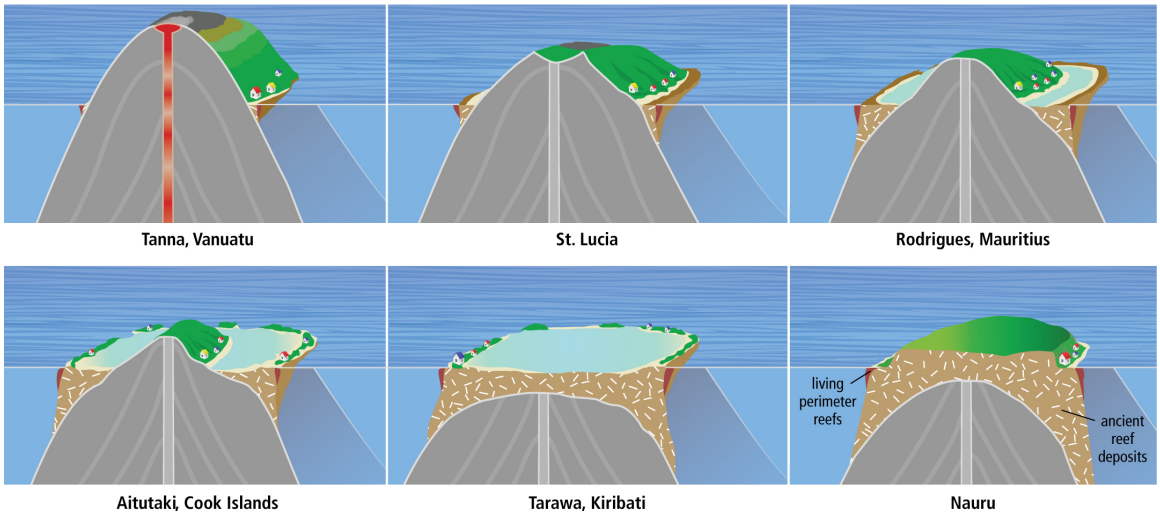

Figure 2.2 Representative tropical island typologies. From top left: A young, active volcanic island (with altitudinal zonation) and limited living perimeter reefs (red zone at outer reef edge), through to an atoll (centre bottom), and raised limestone island (bottom right) dominated by ancient reef deposits (brown and white fleck). Atolls have limited, low-lying land areas but well developed reef/lagoon systems (Nurse et al., 2014).

Small island states are typically less than 10,000 sq km in size and have 500,000 or fewer residents, but vary greatly by geography, social composition, political influences, economic priorities, and climatic conditions (Hess, 1990). Some of the small island nations are single islands (e.g. Barbados), while others are groups or archipelagos of several (Tuvalu), hundreds (Tonga), or thousands of islands (Maldives). Small island states differ greatly in physical make-up, varying

from those consisting of high volcanic mountain ridges (f.e. Grenada and Saint Vincent) to those consisting solely of low-lying atoll islands (f.e. Kiribati and the Maldives) (See Figure 2.2). The small island states are mainly concentrated in the Caribbean, Indian Ocean, and the (South) Pacific.

While small island states are rich in diversity, they also share many similarities such as physical size, proneness to natural disasters and climate extremes, extreme openness of their economies and a low adaptive capacity (Nurse et al., 2014). Small island states consisting of low-lying atoll islands are most vulnerable, due to their small size and low elevation.

Vulnerability is defined by the IPCC as "the propensity or predisposition to be adversely affected" (Nurse et al., 2014). The vulnerability of small island states, and low-lying atoll islands in particular, is discussed based on three components: (1) exposure, (2) sensitivity, and (3) adaptive capacity (e.g. McCarthy, 2001).

2.1.3.1 Physical exposure

From the small island nations, those consisting of low-lying atoll are most vulnerable to sea-level rise. Atolls are annular mid-ocean reefs around a central lagoon occurring in mid-plate settings in the Pacific and Indian Oceans. The reef rim consists of reef islands, composed of sand and gravel, and can vary considerably in size and shape (Woodroffe, 2008). Most atoll islands have an oceanward ridge built by waves to a height of around 3 m above mean sea-level. Analysis of sea-level rise in 27 atoll islands in the Pacific Ocean over the past decades has indicated a rise in sea-level of about 2.0 mm per year (Webb and Kench, 2010) and of 3.9-4.1 mm per year in the Maldives (Khan et al., 2002). Land area in the Pacific remained stable in this period, showing that reef islands are resilient land forms and may not experience large scale loss of land or total inundation in the near future (Webb and Kench, 2010). Kench et al. (2005) simulated sea-level rise and the geomorphological response of the islands in the Maldives and concludes that many of the islands are likely to persist under moderate scenarios of future climate change and sea-level rise. However, there are a range of climate change stresses that could lead to an increase in pace of geomorphic change and tipping points in geomorphology of the islands, such as sea surface temperature increase, ocean acidification, accelerating rates of sea level rise and possible changes in storm frequency or intensity. If a tipping point is reached, atoll shorelines could become rapidly erosive (Webb and Kench, 2010). The magnitude and mode of geomorphic change is likely to vary between islands (Webb and Kench, 2010; Woodroffe, 2008), where islands that have been modified by humans are inherently more vulnerable (Kench et al., 2006).

Many small island states, including many that are not solely consisting of low-lying atolls, are situated in areas prone to natural disasters such as cyclones and ocean swells (Leatherman and Beller-Sims, 1997). Climate change is linked to an increase in incidence and intensity of weather extremes. An increase in incidence of cyclones also affects the incidence of ocean swells. Large deep ocean swells are generated by extratropical cyclones thousands of kilometres from the small island states. Large ocean swells cause considerable damage to beaches, ecosystems, and infrastructure in the Caribbean (Bush et al., 2009) and swells of similar characteristics also occur in the Pacific (Fletcher et al., 2008) and the Indian Ocean (Harangozo, 1992).

Climate change influences sea surface temperatures. Related thermal stress and increased carbon dioxide concentrations are expected to affect the functioning and viability of living reef systems through increased coral bleaching and reduced reef calcification rates (Hoegh-Guldberg et al., 2007; Eakin et al., 2009). During the severe 1998 El Niño bleaching event coral reefs in the Maldives were impacted heavily and some were still mostly degraded 12 years after the event (Tkachenko, 2012). Significant coral bleaching events have occurred in Kiribati, with nearly 100% coral mortality in the lagoon and 62% mortality on the outer slopes during 2002–2003 (Alling et al., 2007). In 2005 a bleaching event impacted approximately 70% of corals impacted around Barbados (Oxenford et al., 2008).

2.1.3.2 Sensitivity

Many small island states rely on few economic activities such as tourism or fishery and are dependent on a narrow range of exports and a high dependence on strategic imports, such as food and fuel (Briguglio et al., 2009). Their vulnerability is further enhanced due to poor infrastructure and limited economic and human resources. In the case of atoll islands, almost all developments and settlements are coastal. As most fertile agricultural areas are close to the sea, as well as most urban centres and major roads, and because the fresh water resources are often vulnerable to salt water intrusion, even a small rise in sea-level can have a large impact (McGranahan et al., 2007; Mimura, 1999; Pernetta, 1992).

Potential impacts of increased erosion and flooding from the sea include loss of land and damages to housing, infrastructure, and industries such as tourism and agriculture. Furthermore, more intense and more frequent extreme events may lead to an increase of recovery time (Nurse et al., 2014). An increase of recovery time may imply that coastal societies will not be able to fully recover from previous extreme events, leading to long-term deteriorations of, for example, agricultural systems, urban water systems and housing infrastructure (Nurse et al., 2014).

Most of agriculture produces in small island states is for subsistence purposes and only in some cases produced for domestic and international markets (Barnett, 2010). For coastal communities in small island states, impacts of climate change such as erosion, increased contamination of groundwater and estuaries by saltwater intrusion, damage by cyclones and storm surges, heat stress, and drought can all impact on food production (Barnett, 2010). Cyclones can be a significant cause for lost agricultural production, for example, in 2003, Cyclone Ami caused over $37 million of damage in Fiji (McKenzie, 2005).

Tourism has become a major economic sector in many small island states over the last 50 years. For example, the tourism sector accounts for about one third of the gross domestic product (GDP) for the Republic of Maldives and provides indirect employment and other opportunities in many other sectors (Ministry of Environment, Energy and Water, 2007). Climate change can have significant direct and indirect impacts on the tourism sector (Bigano et al., 2006). Beach erosion and coral bleaching have found to impact the attractiveness of tourism destinations in, for example, Martinique (Schleupner, 2008), Barbados, and Bonaire (Uyarra et al., 2005).

In the small island nations, and those consisting of low-lying atoll islands in particular, fresh water is a scarce resource. There is only a limited availability of fresh water from shallow aquifers, causing the coastal societies to depend heavily on precipitation as a source of fresh water, and alternatives such as desalinisation have had mixed success (White and Falkland, 2010). The dependency of the islands on rainfall significantly increases their vulnerability to changes in distribution of precipitation due to climate change (Nurse et al., 2014).

2.1.3.3 Adaptive capacity

Even without climate change and associated sea-level rise there are challenges for sustainable development in many of the small island nations (Maul, 1996). High rates of population growth and overdevelopment put pressure on natural resources. Over-exploiting of resources (e.g. overfishing and sand and coral mining) is common as well as pollution problems resulting from high population pressures, and bad practice such as destructive fishing or physical harm to coral reefs due to diving and snorkelling. Such over-exploitation of resources leads to a decline of resources that sustain their economy (f.e. tourist beaches and coral reefs) (Leatherman and Beller-Sims, 1997). Further, rapidly growing demand, land use change, urbanisation, and tourism are already putting strain on fresh water resources (Emmanuel and Spence, 2009; Cashman et al., 2010; White and Falkland, 2010).

This shows that many small island states are already ill equipped to handle existing problems that will only worsen as climate changes (Pernetta, 1992). The relatively small economies of the small

island states combined with the expected high impacts of climate change result in a high burden of potential adaptation costs for small island states, and those consisting of low-lying atoll islands in particular (Nicholls and Tol, 2006).

The high vulnerability to climate change, and sea-level rise in particular, of low-lying atoll nations has resulted in expectations that increased migration and island abandonment will be the ultimate consequence. The threat of sea-level rise to these low-lying atoll nations is one of the most dramatic impacts of potential consequences of human-induced climate change in the coming century. The potential abandonment of entire nations has sparked discussion on the role of small island in international law, human rights, and has made them a key example in the climate change debate.

Further, it has compelled small island states to work together. Small island states recognised their disproportionate vulnerability to climate change, as well as their individual powerlessness in international negotiations. Already in 1990, they formed a negotiation bloc, the Alliance of Small Island States (AOSIS). AOSIS has become a key player in the United Nations Framework Convention on Climate Change (UNFCCC) negotiations (Betzold et al., 2012).

2.1.4 The theoretical links between climate change, migration, and island abandonment

It is likely that the environmental conditions and the socio-economic well-being of populations of small island states will worsen due to climate change unless adaptation measures are adopted to reduce impacts (Nurse et al., 2014). The capacity to adapt on low-lying islands is generally low, due to lack of land of more than 2 meters above sea level, low household and national income, as well as limited access to technology and infrastructure (Barnett and Adger, 2003). Due to the potential high impacts of climate change and low capacity to adapt, the IPCC noted already in the first assessment report that the greatest single impact of climate change could be on human migration (Tegart et al., 1990).

The theoretical links between migration and climate change are explained below: (1) linking climate change with the collapse of coastal societies and island abandonment, (2) linking the high cost of adaptation with a need for migration, and (3) migration as an adaptation strategy.

First, the burden on society and natural resources can become too large in the future due to climate change, which could change social dynamics and priorities regarding migration. Changing social dynamics and priorities could lead to reaching socio-ecological thresholds of change and to a collapse of local socio-ecological systems (e.g. migration and abandonment of islands) (Barnett and Adger, 2003). The theoretical link of long-term sustainability of societies in small island states

and potential abandonment of sovereign nations due to climate change is an example of 'dangerous' climate change. Burdens on resources and the reaction of society will differ between societies depending on how they perceive the risks related to climate change and how they analyse the costs and benefits related to migration. If social-ecological systems are affected by climate change, this will affect people's perceptions of the risks and benefits of migration. For example, if climate change reduces incomes, decreases access to important forms of natural capital, and in the worse case exacerbates morbidity and mortality, people may be more likely to choose to migrate to places they perceive offer a better life (Barnett and Chamberlain, 2010).

Arenstam Gibbons and Nicholls (2006) provide an example of a collapse of a socio-ecological system on an island. Holland Island in Chesapeake Bay, USA, was a booming community from 1850 to 1900, with a population increase from 37 to 253. At the same time, the island experienced high rates of relative sea-level rise in the mid 19th century and the upland area where people made their homes was steadily decreasing. After 1900, the island's population steadily decreased due to lack of space and experienced abrupt abandonment of the remaining population between 1916 and 1918. The abandonment was not triggered by complete inundation, but because critical community services, a critical threshold of change, could no longer be provided (Arenstam Gibbons and Nicholls, 2006). Although this example is not based on a low-lying atoll nation, it shows that many small low-lying islands could be abandoned long before they become physically uninhabitable (Arenstam Gibbons and Nicholls, 2006). These thresholds of change are not well understood and may originate from social as well as environmental processes.

Second, the high cost of adaptation can trigger migration. Coastal societies can adopt three generic adaptation strategies (Bijlsma et al., 1996; Klein et al., 2001):

1. Protect: to reduce the risk of the event by decreasing its probability of occurrence;
2. Retreat: to reduce the risk of the event by limiting its potential effects;
3. Accommodate: to increase society's ability to cope with the effects of the event

The challenge is to understand the adaptation strategies that have been adopted in the past and which may be relevant for the future in these societies (Barnett and Adger, 2003). Adaptation measures such as risk-reduction strategies, sectoral policy initiatives in sustainable planning, disaster management and prevention, integrated coastal zone management, and health care planning should be implemented in an integrative manner in order to be successful (Nurse et al., 2014). Most of the adaptation to date on small islands however, has been reactive responses to climate extremes (Nurse et al., 2014). As yet, only the Thames Estuary 2100 Project for the

protection of London to floods, and the Delta Commission to protect The Netherlands to sea-level rise, have considered long term-adaptation plans to climate change and sea-level rise (Nicholls et al., 2011). Further, adaptation strategies to protect low-lying island states are usually limited and costly. However, extensive land reclamation programmes have been initiated in areas where land pressure is high, such as in vicinity of the capitals of the Maldives and Kiribati. For example, reef islands around South Tarawa in Kiribati have increased substantially in size between 1968 and 1998, mainly driven by land reclamation programmes (Biribo and Woodroffe, 2013). Due to the relatively small population and difficulties in implementing protection measures, forced abandonment seems a feasible outcome. As such, the potential high cost of adaptation for islands is linked to a potential need for migration (Biermann and Boas, 2010; Gemenne, 2011; Nicholls et al., 2011).

Lastly, in addition to a *reactive or forced* response of migration due to impacts of climate change or high costs of adaptation, migration has also been suggested as a potential adaptation *opportunity*, particularly in the context of temporary or permanent out-migrants providing remittances to home-island families, thereby enhancing home-island resilience (Barnett, 2001) and would appear to be a feasible climate adaptation strategy in particular circumstances, including small island states (Adger et al., 2003). Adger et al. (2003) does suggest that due to current inequities in labour flows, this adaptation option is likely to be contested, and may only be a limited option in many parts of the world, including small island states.

These studies and theories on climate change and migration in low-lying islands (and in particular coral atoll nations) focus on permanent migration. This in contrast to, for example, seasonal migration and other temporary migration for employment purposes or health related migration. The main type of temporary migration in small island nations is related to tourism industry and healthcare. However, studies focusing on linking environmental change to temporary migration (e.g. Henry et al., 2003; Henry et al., 2004; Hunter et al., 2014), mostly relate to seasonal differences in, for example, rainfall patterns between regions. Such regional and seasonal differences are less common in small island states and this thesis therefore addresses permanent migration between islands within an island nation (internal migration) and permanent international migration.

2.1.5 Difficulties of linking migration flows and behaviour to environmental change

Despite the abundance of theoretical links between climate change and migration, there is a lack of studies empirically relating climate change and sea-level rise to migration in small island settings (Lilleør and Van den Broeck, 2011; Mortreux and Barnett, 2009, Speelman et al.,

submitted-a (see Chapter 3)). Two case studies in Tuvalu showed that concerns about climate change are currently not a significant driver of migration and do not appear to be of significant influence on those who intend to migrate in the future (Mortreux and Barnett, 2009; Shen and Gemenne, 2011). The lack of studies linking migration and environmental change in small island settings show that the widespread assumption about migration as the most likely option adaptation strategy is based on insufficient evidence (Mortreux and Barnett, 2009).

The responses of coastal societies to climate change depend on the expected impacts of climate change and their adaptive capacity. The adaptive capacity of both society as well as ecological systems and the constraints and barriers regarding adaptation are not well understood. Perfect adaptation based on a perfect foresight of slow, predictable and smooth climate trends is highly unrealistic (Schneider et al., 2000). Further, adaptation to climate change is not just limited by technological and economic factors, but also by the values, perceptions, processes and power structures within society, factors which are often ignored in adaptation practices and research (Adger et al., 2009; Grothmann and Patt, 2005).

Adaptation and adaptive behaviour is a clear example of human decision-making under uncertainty and it would be beneficial to recognise socio-cognitive variables, such as motivation and perceived abilities, as important determinants of human action and associated adaptive behaviour (Grothmann and Patt, 2005). A similar argument can be made for migration in relation to environmental change. As there are so many social, economic and environmental factors involved in migration decision making it has been difficult to establish a clear causative relation between climate change and population dynamics (Locke, 2009). Migration decisions are greatly influenced by individual characteristics such as age, gender, education, skills, risk-taking capacity, capacity to face new situations, etc. (Boncour and Burson, 2010). Given the volume of recent academic and policy publications about the impacts that climate change might have on migration, the number of empirical studies dealing with migration and the environment is surprisingly small (Black et al., 2011a).

The potential effects of migration on small island states are also subject to discussion. An increase in migration from small islands can have both negative as well as positive feedbacks. Barnett (2001) found that migrants provide remittances, enhancing the resilience of their home island. However, migration from outer islands to the capital cities has increased risk of the impact of inundation and flooding in the South Pacific. The traditional system of land ownership in the South Pacific leaves the migrants unable to buy or rent land on the capital island, leaving them to settle in low elevation areas, which are more likely to be affected by sea-level rise (Nicholls and Mimura, 1998).

2.2 Broadening the analysis of migration beyond environmental contexts

The previous section introduced the theoretical link between migration and climate change largely from an environmental science perspective. This perspective can be illustrated using the First Assessment Report (FAR) of the IPCC (Tegart et al., 1990), where migration is mentioned as the potentially most threatening short-term effect of climate change on human settlements. The report states that loss of housing, living resources, or social and cultural resources may cause migration due to climate change. Physical impacts are *directly* projected on human behaviour. Estimating flows of environmentally induced migration and numbers of potential environmental refugees are often based on such projections. In contrast, migration scholars have focused on socio-economic, cultural and political factors.

In recent years it has been acknowledged that links between environmental change and migration are complex and operate through a large variety of drivers (e.g. Black et al., 2011a). The difficulties of linking migration to environmental change, as illustrated in the previous section, is an example of such complexity. Understanding of these linkages and drivers requires advances in empirical migration research. Such advances depend on increased collection of quantitative data; adoption of more sophisticated statistical modelling approaches; and greater collaboration between environmental and migration researchers (Fussel et al., 2014). Understanding future migration flows, including the potential role of the environment, requires an interdisciplinary approach, as both the linkages between ecological and social systems, as well as individual or household decision-making processes, must be considered.

This section first provides a *demographic* perspective to migration on the basis of a historic overview of theories of migration. Next, an integrative framework of demography and environmental change is presented and lastly, behavioural theories are discussed.

2.2.1 Traditional theories of migration

Ravenstein developed the first theory on drivers for migration in the 1880s by postulating 11 drivers of migration (Grigg, 1977). These drivers were (1) the effect on migration patterns of distance, (2) migration proceeds step-by-step, (3) long-distance migration is usually driven by commerce or industry, (4) each migration flow produces a counter flow, (5) people living in urban centres are more likely to migrate, (6) females move more often within their country whereas males more frequently venture beyond, (7) most migrants are adult and families are less likely to move, (8) large towns grow quicker than their natural increase, (9) migration increases as industry

and commerce develop and transport improves, (10) the most important migration flow are from rural to urban areas, and (11) the most important reason of migration is economic. Ravenstein based his laws on empirical analysis of census data from the United Kingdom and later extended his analyses to the United States and Europe. Ravenstein's pioneering work has been the stimulus for subsequent research on migration flows its theoretical basis (Grigg, 1977).

Most of the early literature focuses on the importance of distance. For example, Stouffer (1940) stated that the influence of distance cannot be expressed enough and claimed that the number of persons going a given distance is proportional to the number of opportunities at that distance and inversely proportional to the number of intervening opportunities. The same holds for migration between urban centres, where urban-urban migration is a function of the distance separating cities, as the effort and costs to migrate increase with distance (Zipf, 1946). Analyses of migration flows are often based on gravity theory (Grigg, 1977; Zipf, 1946). Gravity models are based on population size and the distance between both the origin and destination of migration. Distance is expected to have a negative influence on migration, whereas population size at both origin and destination is expected to be positively related to the size of migration flows.

Lee (1966) was the first scholar to challenge the complete framework of Ravenstein and proposed an extension of the already existing framework of 'push and pull factors' influencing migration. The framework of Ravenstein largely focuses on explaining the size and direction of migration flows. Such an approach is interesting in terms of geography and characteristics of place of origin and destination. Lee (1966) acknowledges the importance of this approach, but adds another level of personal decision-making and behaviour to the analyses of migration. Lee (1966) shows that the relationship between origin and destination can be defined by means of push factors and pull factors, intervening obstacles, and personal factors. Push factors are triggers for emigration. Pull factors include a wide range of perceived advantages of the area of destination. Furthermore, Lee (1966) argues that for an individual to decide to migrate intervening obstacles have to be overcome. Lastly, Lee (1966) argues that there are personal factors influencing individual thresholds and facilitate or retard migration and that often it is not the actual factors at the origin and destination that results in migration, but the perceived advantages and disadvantages, which are influenced by personal sensitivities, intelligence, stage of life, and awareness of conditions elsewhere. The theory of Lee (1966) is still widely applied in migration studies. The main focus of applications however, has been subject to change. For example, Todaro (1969, 1971) and Stark and Taylor (1989) mainly focus on rational economic reasoning, whereas more recent literature also includes other factors such as gender differences, or decision-making on different levels (f.e. defining a household as a decision-making unit) (Brettell and Hollifield, 2000).

Theoretical advancements have been made since the influential theory of migration of Lee (1966). However, the development of a single theoretical framework of migration has proven to be difficult. An international, multi-disciplinary team of scholars provided a comprehensive review of migration theories (Massey et al., 1998). This identified six separate bodies of theories: (1) neoclassical economics (Todaro, 1980), (2) the new economics of labour migration (Stark, 1991), (3) segmented labour market theory (Piore, 1979); (4) world systems theory (Sassen, 1990); (5) social capital theory (Massey et al., 1994); and (6) the theory of cumulative causation (Massey, 1990). Massey et al. (1998) evaluated these theories to empirical research of main migration systems and discerned the degree of support for propositions linked to each theory. The main focus of these theories is based on economic or labour theories. These theories of migration are applicable under different circumstances and lack the general applicability of the 'push and pull' framework of Lee (1966). This is illustrated by the review of Massey et al. (1998), as they conclude that the validity of each theory essentially depends on different stages of economic development of the region in which the research was undertaken and different empirical circumstances.

In line with the findings of Massey et al. (1998), in a special issue of the journal 'Global Environmental Change' on Migration and Global Environmental Change published in 2011 (Black et al. (eds), 2011b), it was acknowledged that a comprehensive understanding of economics, politics, identity, risk, and the embedded history of migration in any specific place is *critical* to the core questions of migration and environmental change. However, the demographic and socio-economic theories of migration mentioned above focus mainly on socio-economic reasons of migration and factors of environment and environmental change are largely unrepresented.

The recognition that both socio-economic factors *and* environmental processes can, and in fact need to be, considered in order to better understand historic, contemporary, and future migration flows is an idea central to this thesis and therefore builds on the theoretical work of Black et al. (2011a). The framework 'Drivers of Migration' presented in the special issue of 'Global Environmental Change' by Black et al. (2011a) provides a practical tool to study migration flows and migration behaviour and is further explained in the next section.

2.2.2 Integrated framework of migration and the environment

Black et al. (2011a) presented an approach to address the sensitivity of existing migration drivers to environmental change, based on the understanding that migration is a significant, growing, and complex phenomenon. The approach acknowledges the reality of migration and that many people across the world are already migrating. People migrate for complex reasons, to improve their

economic situation, to be close to friends or family, for political or safety reasons, or to remove themselves from environmental or other threats, and often only temporarily.

The framework of Black et al. (2011a), developed for the UK Foresight project on migration and global environmental change (Government office for Science, 2011), is an effort to provide an integrative view of demographic processes and environmental stresses and aims to provide an encompassing range of drivers that might affect the volume, direction, and frequency of migration movements, as well as the different levels of analysis at migration might be considered. The framework has four components: (1) A distinction between types of migration, (2) identification of five families of drivers of migration, (3) incorporation of agency on how drivers translate into outcomes, and (4) the incorporation of environmental change as a direct influence on migration, and also as an indirect influence through changes to other families of drivers of migration. (The five families of drivers of migration identified by Black et al. (2011a) are: (1) demographic, (2) economic, (3) social, (4) political, and (5) environmental drivers (see Figure 2.3)).

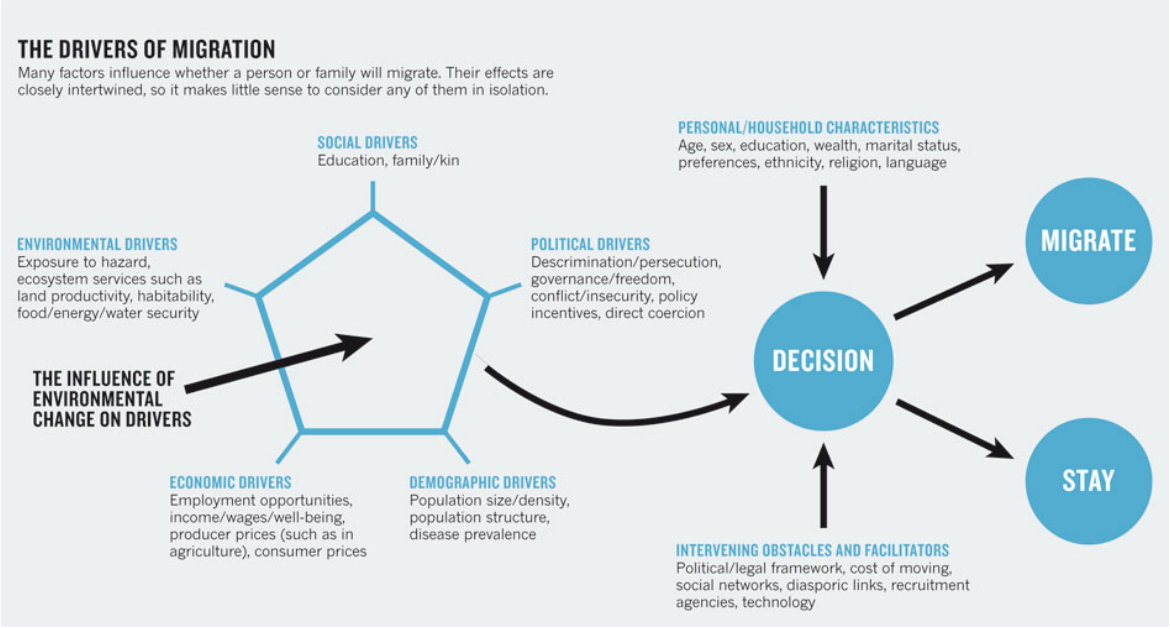

Figure 2.3 Drivers of Migration (Black et al., 2011c).

The five drivers of migration have similar characteristics to push-and-pull factors as defined by Lee (1966). Demographic factors include population size and structure, birth rates, and prevalence of diseases affecting morbidity and mortality. An example of an economic driver of migration is income and wage differentials; the social driver includes factors such as family expectations and migration for educational purposes; and political drivers include the effects of policies or breakdown of governance and conflict. The environmental driver includes a population's exposure to hazard and the availability of ecosystem services. These factors are closely intertwined and should not be considered in isolation. The framework acknowledges that a

combination of drivers together lead to a migration decision and considers the environment to influence these drivers. It is important to recognise that the interactions between the different drivers determine the size and direction of migration flows.

2.2.3 The Theory of Planned Behaviour

The frameworks of Lee (1966) and Black et al. (2011a) mainly focus on explaining migration flows and the characteristics of place of origin and destination. Although personal characteristics are included in the framework of Black et al. (2011a), the considerations of individuals and related intentions to migration and migration behaviour do not play an important role in the framework. In fact, most migration theories and empirical work related to migration (and the environment) largely neglect such differences and focus on larger scale movements and characteristics of place of origin and destination. However, the personal background and development of attitudes to migration are important in individual considerations to migration. Insight in how personal background and attitudes relate to individual migration behaviour help to understand the larger scale trends. This can be illustrated by work done on an empirical level. When people are asked why they migrated, answers almost always cluster around economic and social factors, with environmental factors rarely mentioned, even when surveys specifically ask about such factors (Black et al., 2011a). Hence, Black et al. (2011a) argues that this empirically driven approach assumes that migrants have agency and are both self-aware in terms of their motivation for movement, and willing and able to express these motivations, and that these assumptions are not necessarily valid.

However, in other research disciplines such as communication and psychology research, behavioural theories have been developed and used that help address these issues. These behavioural theories break down the development of behaviour in several components and in different layers of decision-making. An important concept in these theories is the development of an intention for a behaviour. By linking the intention of an individual to several components, a researcher can assess each component to the development of intention. Such models can also be used in migration research, and have been used, although sparingly, over the past decades. This thesis addresses these issues by using the well-established Theory of Planned Behaviour (Ajzen, 1991) as a framework to analyse migration behaviour (see Figure 2.4).

The theory is based on the assumption that human beings in general behave in a rational manner and that they use available information to perform (or not perform) a certain action. The theory postulates that there are three main factors influencing intention. The first factor is the attitude towards the behaviour. Attitude describes the individual's positive or negative evaluation toward

the behaviour. The attitude can be subdivided into two components: (1) *Instrumental Attitude*, and (2) *Affective Attitude*. The *Instrumental Attitude* describes the individual's evaluation regarding perceived costs and benefits related to migration. These include economic considerations, but also conscious considerations of other opportunities such as education, or availability (or lack of) services, etc. *Affective Attitude* is based on an individual's emotional feelings or affective response toward the behaviour. The second factor describes *Subjective Norms*, or the person's perception of social pressure to perform the behaviour. The third factor is the *Perceived Behavioural Control*. This factor describes the person's perceived self-efficacy or ability to perform the behaviour. If these three factors are positive, a person is more likely to have a positive intention to perform the behaviour. The importance of each factor depends on the studied behaviour. Positive intention generally translates into actual behaviour. However, obstacles such as habit formation and other environmental constraints can cause a person with a positive intention to refrain from performing the planned behaviour. In contrast, skills, knowledge, and other facilitators can have a positive effect. Implicit to the Theory of Planned Behaviour are factors influencing attitudes, norms, and perceived behavioural control. These *Background Factors* affect the motivational beliefs as postulated in the Theory of Planned Behaviour, which in turn predicts intention. *Background Factors* include demographic variables such as level of education, age, marital status, personality traits, and other individual differences that can influence behaviour indirectly (Fishbein, 2000).

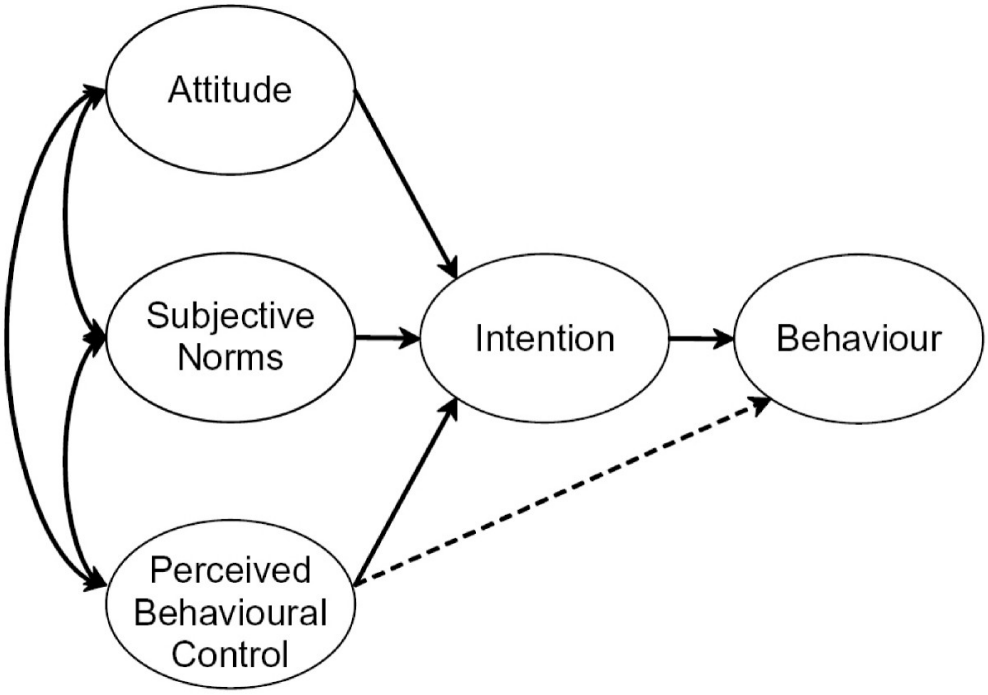

Figure 2.4 The Theory of Planned Behaviour (Ajzen, 1991).

The role of the environment in migration decision-making is not explicitly included in this theoretical framework. Although one could argue that environmental pressures influence the *Instrumental Attitude* and the *Affective Attitude* by, for example, altering economic possibilities, quality of life, feeling of safety, etc., such considerations are difficult to distil from the framework explicitly. Scholars looking at migration flows and the drivers of migration faced a similar problem. Black et al. (2011a) defined the drivers of migration and explicitly included environmental factors and environmental change to drivers of migration to deal with this issue. This thesis, in addition to *Instrumental Attitude* and the *Affective Attitude* toward migration behaviour, introduces an *Environmental Attitude* to migration behaviour. By *explicitly* including environmental considerations to the development of intentions to migrate, individuals perception of environmental factors such as environmental degradation or the perceived threat of climate change and sea-level rise to their place of residence and its effects on the development of intentions to migrate can be assessed. The opinions and views of individuals about environmental issues can in this way be de-coupled from socio-economic considerations and the effects of each different component can be assessed individually.

2.3 The Maldives: A vulnerable low-lying small island state

What makes the case of the Maldives appealing as a case study, and similarly Pacific islands and other small island states, is the level of exposure and sensitivity to sea-level rise as a result from climate change. The Maldives has played a large role in the climate change debate and has received special attention, as there is a certain dramatic appeal about an island nation facing total inundation. Further, the Maldives has a well-developed statistics department and has been subject of several vulnerability and climate impact assessments. In this thesis, the Maldives is used as an exemplary case study of a small island state vulnerable to rising sea levels.

2.3.1 Geography and population distribution

The Republic of Maldives, at 298 sq km, is the sixth-smallest sovereign state in terms of land area. The land is divided into 1,192 coral islands, of which 96% are less than 1 sq km in area. Shallow lagoons enclosed by coral reefs surround the islands with an average height of only 1.6 meters. The Maldives is a Sunni Muslim society and its constitution is based on sariatu, the Maldivian interpretation of the traditional sharia. The Maldives is the 9th most densely populated country in the world (World Bank, 2015). In 2006, 193 islands were inhabited and 91 islands had been developed as tourist resorts. The country had a population of 298,968 in 2006, excluding guest workers, resulting in a highly densely populated nation with 1,003 people/sq km. Preliminary results of the 2014 census report that the population has increased to 399,939 (National Bureau

of Statistics, 2015), including an estimated 58,683 guest workers. However, an earlier estimate for guest workers in 2010 was 110,000 people (U.S. Department of State, 2010) and the numbers seem still to be growing, so the 2014 census may well be an underestimate of the total population including guest workers. The Maldives consists of 19 administrative regions called Atoll Districts, roughly corresponding to the natural groups of atolls, and an administrative region of the capital city Malé (see Figure 2.5). The urban area of the capital city of Malé (Greater Malé) consists of several additional islands in the vicinity of the capital, including the artificial island Hulhumalé, the airport island Hulhulé, and Villingili.

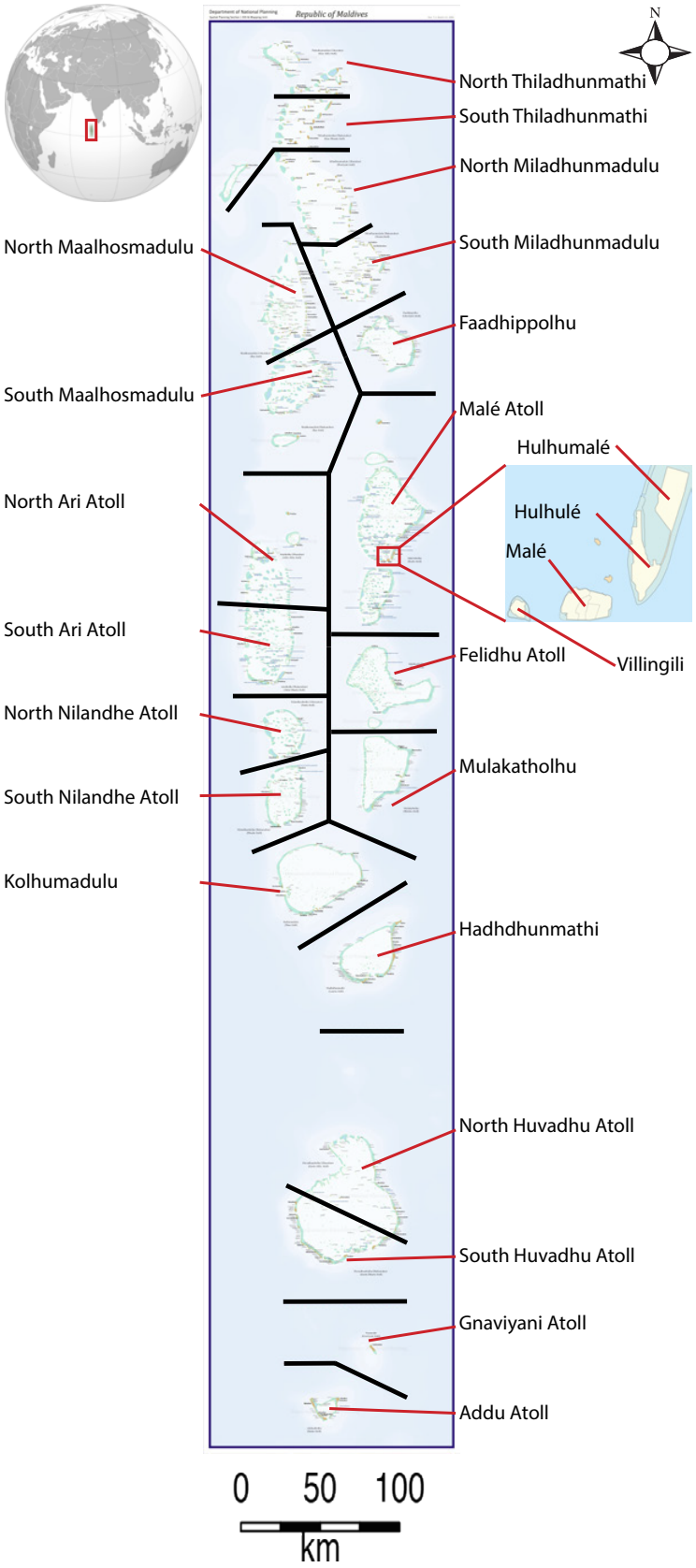

Figure 2.5 Map of the Maldives.

The capital island of Malé is the centre of economic development, services, and political power and it has grown to a population of about 127,079 on an island of 1.98 sq km, resulting in a

population density of 64,148 people per sq km (National Bureau of Statistics, 2015). By comparison, the population density of Manhattan is, at 27,673 per sq km (U.S. Census Bureau, 2015), less than half that of Malé. The neighbouring islands Hulhumalé and Villingili have a population of 15,769 and 7,790, respectively. Malé and its environs is the only real urban area in the Maldives. The population of the Maldives is dispersed. Only 11 other islands have a population of over 2,500.

Due to their limited size, many of the islands have developed specific functions and the government encourages this. For example, all trash from Malé and neighbouring resorts is deposited on the artificial landfill island Thilafushi and is burned or recycled there. Next to garbage disposal, the island also houses some heavy industry. Other specific economic and land use functions for islands include tourism, airports, residential, and agriculture (see Figure 2.6).

Figure 2.6 The photographs above show four examples of islands with specific functions. a) The capital city of Malé is heavily developed and is the centre of the economy and political power. b) Thoddhoo is an agricultural island, most famous for its watermelon production. c) Thilafushi (in the background) is the garbage landfill and industrial island near Malé. d) Hudhuranfushi is one of the designated tourism (resort) islands (Photographs by the author, March 2015).

Tourism accounts for about 28% of GDP and 68% of Maldives foreign exchange receipts and is the most important industry of the country. Tourism has developed since the first resort opened in

1972. Until 2009, tourism was only developed on 'resort' islands, separate from local communities. Thanks to a change in regulations by the first democratically elected president Nasheed in 2009, local guesthouse tourism is starting to develop on inhabited islands as well rather than just on privately owned resorts, leading to increased (economic) benefits for local communities. In 2012, 958,025 tourists visited the Maldives (Ministry of Planning, 2013). The second industry in the Maldives is fishing, which accounts for about 20% of the work force and 10% of GDP.

2.3.2 Vulnerability to climate change

As shown in section 2.1.3, all atolls and atoll nations are vulnerable to climate change. The specifics of the Maldives are discussed here.

Eighty per cent of land area in the Republic of Maldives has an elevation of less than one meter above sea surface and is thus highly vulnerable to even slight changes in sea level (Khan et al., 2002; Ministry of Environment, Energy and Water, 2007). Between 2000 and 2006, 45% of all inhabited islands of the Republic of Maldives have been flooded at least once; about 20% of the islands have been inundated regularly (Shaig, 2006). Most of these floods are driven by monsoonal winds, which is considered the most common in the Maldives. In addition, the Maldives is vulnerable to ocean swells. The Maldives experienced examples of such inundation events in 1987 and 2007. Unusually large deep ocean swells, originating from about 6000 km away to the south west caused major flooding, damages to property and sea defenses and erosion of reclaimed land in 1987, including Malé (Harangozo, 1992). With the help of the Japanese government, a series of breakwaters were constructed around Malé, protecting it from storm surges and floods (Pernetta, 1992). In 2007, the Maldives experienced major flooding due to a similar ocean swell event, although Malé was not so adversely affected (Maldives Department of Meteorology, 2007). This series of swells impacted an estimated 68 islands in 16 atolls. More than 500 housing units were damaged and 1600 people were evacuated (UN Office for the Coordination of Humanitarian Affairs, 2007). Climate change and its associated sea-level rise could lead to a significant increase in inundation events and permanent loss of land, posing an immediate threat to the small island state (Nurse et al., 2014).

Because most of the islands have a relatively small land surface, almost half of the residential area is within 100 meters of the shoreline. Furthermore, 80% of the powerhouses, 75% of communications infrastructure, 90% of waste disposal sites, and virtually all tourist accommodations have been built within 100 meters of the coastline (Ministry of Environment, Energy and Water, 2007). The scarcity of land and the small surface area of the islands and their

low elevation make it impossible for the population to retreat inland to higher ground (Ministry of Environment, Energy and Water, 2007).

Furthermore, the shallow aquifers are highly vulnerable to salt intrusion, affecting availability of fresh drinking water, agricultural production, and local ecosystems. A majority of the population already depends highly on rainwater as the main source of fresh water and almost all food items, except for tuna and coconut, are already being imported (Ministry of Environment, Energy and Water, 2007). Ninety per cent of the households outside Malé use rainwater as the principal source of drinking water. Only on the capital island of Malé do people have access to desalinated water, which is essential given the high population and its high water demand.

During the severe 1998 El Niño bleaching event coral reefs in the Maldives were impacted heavily and some were still mostly degraded 12 years after the event (Tkachenko, 2012). Increased coral bleaching and reduced reef calcification rates are expected to affect the functioning and viability of living reef systems (Hoegh-Guldberg et al., 2007; Eakin et al., 2009). Changes in the health of reef systems can in turn affect the tourism and fishing industries in the Maldives; industries on which the country most depends.

Lastly, indicative of the vulnerability of the Maldives to environmental impacts are the damages the island state suffered from the 2004 Tsunami in the Indian Ocean. The Maldives was severely impacted with more than 82 confirmed deaths and 26 people missing, and damage and destruction on a national scale (Hermann et al., 2006). The economic damage alone is estimated to account for roughly 62% of the Maldivian GDP (Ministry of Planning and National Development, 2005). According to the self-reported census data of 2006, almost 4000 people were still displaced due to the 2004 tsunami 18 months later.

2.3.3 The Maldives in the climate change debate

The government of the Maldives was the first nation to put the impacts of climate change and sea-level rise on the international policy agenda after the series of coastal flood events in 1987. The Maldives highlighted the issue during the Commonwealth Heads of Government Meeting and at the Summit Meeting of the South Asian Association for Regional Cooperation in 1988. Further they hosted the Small States Conference on Sea-Level Rise in 1989 (Lewis, 1990a; Shihab, 1989) followed by a United Nations Environment Programme (UNEP) impact assessment report (Pernetta and Sestini, 1989).

The Maldives continued to be on the forefront of climate change discussions. Despite its small size and relatively low population it has played an important role in the development of the AOSIS of

Small Island Development States (SIDS) and in the UNFCCC Conference of Parties (COP) negotiations. For example, in 2007, the Maldives called on the UN Human Rights Council to discuss climate change and its links with human rights and organised a Small Island States Conference on the Human Dimension of Global Climate Change. This culminated in the adoption of the "Human Rights and Climate Change" resolution by the UN Human Rights Council in 2008.

The discussion about impacts of climate change on the Maldives gained new momentum after former president Mohamed Nasheed won the first democratic election in the Maldives in 2008. Mohamed Nasheed became a high profile figure in negotiations about mitigation and adaptation to climate change, emphasising the country's vulnerability to sea-level rise. In preparation for the negotiations in Copenhagen he said: *"We did not do any of these things. But, if things go business as usual, we will not live, we will die. Our country will not exist"* (Eastly, 2009). In 2009, he also organised the first underwater cabinet meeting and starred in the documentary "The Island President" in 2011. He raised the profile of the Maldives in international politics and used the Maldives as a key example of a small island state in danger of total inundation. In 2015, the Maldives assumed the Chairmanship of the AOSIS.

Island abandonment, increased (international) permanent migration, and (forced) relocation are central themes in these discussions and the Maldives have been linked to these processes since decades. The high vulnerability of the Maldives to climate change and its relevance in the academic and political debate together makes it an interesting and representative case study with widespread implications for other small island states.

2.4 Overview of the following chapters

The four research questions defined in Section 1.1 each require distinct and complementary research methods. Each research question is dealt with in a separate chapter that presents independent, and complementary research in the format of stand-alone scientific publications and presented in Chapters 3 to 6, respectively. The methods are described in detail in each of these chapters. Here these Chapters are outlined.

2.4.1 Present drivers and the potential role of climate change on migration in small island settings

Drivers of migration are often addressed or identified in separate research articles and research projects, focusing on, for example, economics or the potential role of the environment. Migration research based on different drivers of decision-making is often lacking. Chapter 1 contributes to the advancement of knowledge about migration in small island settings by conducting a

systematic review of previous empirical research conducted in small island settings. This identifies the determinants recognised in these studies that influence migration in small island settings. To group the determinants identified in the systematic review, the Drivers of Migration of Black et al. (2011a) are used. By using this theoretical framework a holistic overview is developed discussing migration in small island setting, without focusing solely on the environment or other drivers. The overview of existing research provided in the systematic review acts as an empirical foundation for the research presented in Chapters 4 to 6, respectively.

The systematic review closely follows the reviewing methods as applied by Berrang-Ford et al. (2011). A systematic review provides a review of the literature that addresses a specific research question based on clear eligibility criteria. Because of the pre-defined selection criteria and a clear methodological systemisation, systematic reviews are transparent and reproducible and are thus based clearly defensible criteria rather than ad hoc selection or researcher bias (Berrang-Ford et al., 2011). Such systematic approaches have been developed within social sciences (Waddington et al., 2012) and are applied predominantly in health sciences (Berrang-Ford et al., 2011). The standardised criteria for reviews have been criticised for a bias to quantitative data through the strict criteria for selection of journal articles. However, more flexible methods have been developed to review diverse and complex literature bases, depending on the question addressed. The methods presented in the systematic review allow for the inclusion of quantitative and qualitative research papers.

2.4.2 Migration flows in a small island setting: A case study of the Maldives and its wider implications

Empirical research of migration in small island settings embedded in socio-economic *and* environmental contexts is lacking. Based on extensive demographic, socio-economic, and environmental datasets, the characteristics of migration flows in the Maldives are analysed in Chapter 4.

The size of migration flows between all islands in the Maldives is predicted based on island-level characteristics. Models consisting of migration flows within a nation or region are often based on gravity theory (Grigg, 1977; Zipf, 1946). Gravity models are based on population size and the distance between both the origin and destination of migration. Chapter 4 uses a gravity model as a first estimate of migration flows and adds socio-economic and environmental island-level information to add to their relationship. A wide range of studies have been performed in recent years modelling migration flows driven by both socio-economic, as well as environmental data using gravity models (e.g. Curtis and Schneider, 2011; Henry et al., 2003; Kim and Cohen, 2010;

Marchiori et al., 2012). The data is analysed using Poisson generalised linear mixed effects regression models.

2.4.3 Contemporary migration intentions in the Maldives: The role of environmental and other factors

Chapter 5 looks into contemporary migration behaviour and intentions of individuals. In addition to analysing migration flows, individual differences and processes are important in understanding contemporary and future migration behaviour and add another layer of understanding to migration in a small island (or any other) setting.

Chapter 5 is based on quantitative questionnaires completed in the Maldives between 5th February 2015 and 24th March 2015. The questions of the survey closely follow the Theory of Planned Behaviour of Ajzen (1991), with the addition of an *Attitude to Environment*, and based on the identified determinants as described in Chapter 3. This study adds to previous research by analysing how personal characteristics and attitudes influence intentions to migrate in a small island setting. Special attention is focussed on how Maldivians experience the current and future role of the environment in their migration behaviour and how the environment and impacts of climate change could potentially influence their future behaviour.

2.4.4 Agent-based model simulation of future migration and demographic change in a small island setting

Based on the insights presented in the previous chapter, migration processes are further explored in Chapter 6. An agent-based model is developed to simulate demographic change in a small island setting and links demographic processes with both development and environmental characteristics of islands in the Maldives. Simulations of internal migration from 1985-2014 are presented and these are used as a basis to explore demographic change up to 2050 for the small island state. Interactions between different demographic, environmental, policy, and international migration scenarios are discussed.

Agent-based methods offer a tool to simulate emergent migration patterns as a complex adaptive system on the nexus of climate change and demography (e.g. Kniveton et al., 2012). An agent-based model is a computational model simulating the actions and interactions of individual agents. By defining explicit migration decision-making processes for individuals, migration flows can be simulated. As such, complex and potentially unforeseen interactions through the interaction of multiple agents can be identified (Epstein, 2006). Therefore, it provides an additional valuable empirical method for analysing migration. There is a range of existing models

and theories available which model decision-making processes related to adaptation and coastal processes using agent-based modelling. The coastal models focus mostly on the interplay between coastal processes and economics (e.g. Fontaine, 2010; Franck, 2009; Murray et al., 2011). In addition, there is a range of models exploring the links between migration and the environment (e.g. Axtell, 2002; Kniveton et al., 2012; Kniveton et al., 2011). Three of these models that informed the model developed here are described below.

Axtell (2002) developed a landmark agent-based model. The model replicates important demographic trends from historical records of the Kayenta Anasazi in the Longhouse Valley in the United States from about 1800 B.C. to 1300 A.D. The agent-based model was based on annual fluctuations in agricultural production that were estimated using paleo-environmental data and archaeological data. The agents are farmers, who decide where to locate their fields and where to locate their settlements, while nutritional needs constrain their fertility. The model shows that agent heterogeneity is important to the high fidelity of the model. The model constructed by Axtell (2002) is very detailed and complex and also shows that the abandonment of the valley around 1300 AD cannot solely be explained based on environmental variations, supporting the idea of breaching of socio-environmental thresholds.

Kniveton et al. (2011) divided the agent-based model Migration Adaptation to Rainfall Change (MARC) into four component levels: (1) structural, (2) institutional, (3) individual and (4) household. Structural and institutional processes provide the agent with information, individual processes indicate individual cognition and decision making, and household processes represent interactions between agents and network development. The model focuses specifically on rainfall variability as a key structural component and influences the other drivers of migration. This means that the effect of rainfall variability is mediated through other determinants, such as employment opportunities, limited access to natural resources, and ecological vulnerability. These factors have social, economic, demographic, political and environmental dimensions, and Kniveton et al. (2011) uses the MARC model to implicitly model the influence of changes in rainfall on these drivers to explore how individual behaviour leads to macro level behaviour. Similar to the agent-based model presented in this chapter and analyses in the previous section, Kniveton et al. (2011) uses the Theory of Planned Behaviour to break down the migration decision-making process.

Kniveton et al. (2012) builds on this experience and presented a model based on the Theory of Planned Behaviour and that explicitly simulates the perception of an agent to migration behaviour using migrant networks. Agents in the model are defined as individuals based on age, gender, marital status and geographic location. The attitude of an agent towards migration behaviour is

represented as a probability of migration, based on their personal attributes and rainfall variability in the past three years.

These three papers are representative of the development of agent-based models in migration-environment nexus in the past decade. The agent-based model developed in this thesis and presented in Chapter 6 builds on these earlier models. This new agent-based model is grounded in the Conceptual Model of Migration, which combines the Theory of Planned Behaviour (Ajzen, 1991) and the Drivers of Migration of Black et al. (2011a) and further expands on explicitly modelling behavioural processes.

2.4.5 Conclusions and recommendations

Lastly, the implications of the research are summarised and discussed and placed in a broader perspective in Chapter 7. This includes linking the results in the Maldives to the wider question about migration and low-lying islands under climate change. Conclusions are drawn and recommendations for further work are made.

2.4.6 Summary

The wide range and complementary methods used in this thesis provide a solid basis for analysing migration behaviour and migration flows in small island settings and potentially other settings. This thesis presents a systematic review; historic migration flow analysis on the level of communities using large database statistics; explores individual migration intentions by means of quantitative interviews; and lastly explores potential future demographic pathways based on a combination of scales by using an agent-based model. Each chapter provides novel methods to analysing migration behaviour. This wide range of different methods and perspectives together provide an in-depth and multidisciplinary analysis of migration processes in small island settings.

Chapter 3 Present drivers and the potential role of climate change on migration in small island settings

3.1 Abstract

Migration is often mentioned as a major potential impact of climate change for small island settings, especially on low-lying atolls. This paper presents a systematic review of the determinants of migration in small island settings using the published literature. Forty-five distinct determinants were identified based on twenty-four independent papers concerning present migration behaviour. The most mentioned determinant is perceived employment possibilities at destination, or lack thereof at the place of origin. Other determinants that were mentioned by more than five papers are age, education, and migrant networks. Most papers (63 per cent) are based on South Pacific islands and twenty-three determinants have only been identified by one or two papers. Three papers focus explicitly on climate change and migration. Common migration processes between the small island settings include the importance of educational and employment opportunities and the central role of the capital city in attracting migration. Differences include the size of migrant networks and related remittances and their influence on migration. Despite the high profile of small islands in the climate change debate, this review demonstrates that there is surprisingly limited empirical understanding of contemporary migration flows and behaviour in these settings. To better understand how migration flows will develop in small island settings in the future under changing climate, it is essential (1) to develop a better baseline of contemporary migration and its controls, and (2) to improve understanding of both the socio-economic *and* the environmental components of migration.

Keywords: Migration, small island nations, climate change

3.2 Introduction

The potential threats of climate change and sea-level rise to small islands are well established (Nurse et al., 2014). Related climate drivers include sea-level rise, storms, increasing air and sea surface temperatures, ocean acidification, and changing rainfall patterns. These are in turn likely to impact the ecosystems on which people living on small islands depend, including coastal erosion and inundation, salinisation of fresh water lenses, coral bleaching, changing abundance and distribution of fish species, and agriculture. Further impacts on various key economic sectors such as tourism and ports/shipping could be significant.

Global analyses suggest that island regions will experience the largest relative increase in flood risk due to sea-level rise in the coming century (Nicholls et al., 1999; Nicholls, 2004), and low-lying atoll regions appear to be consistently vulnerable across a wide range of scenarios (Nicholls and Tol, 2006). These studies all reinforced the high vulnerability of small island states and especially low-lying atoll islands.

The first papers and Intergovernmental Panel on Climate Change (IPCC) assessment on climate change and its impacts on small islands in the early 1990s already suggested that sea-level rise could lead to total inundation of small low-lying islands (especially coral atolls) and mentioned migration and ecological refugees as the major potential impact of climate change for small island states (Lewis, 1990b; Pernetta, 1989, 1992; Tegart et al., 1990). This view has been reiterated in all subsequent IPCC assessments (Bijlsma et al., 1996; McCarthy et al., 2001; Mimura et al., 2007; Nurse et al., 2014; Watson et al., 1997; Zinyowera et al., 1995). More recently, the potential high costs of adaptation to sea-level rise and climate change for islands was suggested as a driver of migration (Biermann and Boas, 2010; Gemenne, 2011; Nicholls et al., 2011).

However, migration is a complex process and linkages operate through a large variety of drivers (e.g. Black et al., 2011a). Understanding future migration flows, including the potential role of the environment, requires an interdisciplinary approach, as both the linkages between ecological and social systems, as well as individual or household decision-making processes must be considered. It is therefore fundamental to consider existing migration flows and contemporary migration behaviour when analysing potential future changes in migration including the potential effects of climate change.

Rather than thinking about the future, what is known about present migration in small island settings to provide an empirical foundation for migration studies, including the potential role of climate change? In this spirit, this paper conducts a systematic literature review on permanent migration in small island settings. It focuses on answering what determinants are important in

observed migration behaviour on small islands and the implications of this for future research. First, the review methods and selection of papers will be discussed. Second, the study sites will be described. Third, the observed determinants will be presented. This is followed by a discussion and conclusion.

3.3 Review methodology

A systematic review provides a review of the literature that addresses a specific research question based on clear eligibility criteria. Because of the pre-defined selection criteria and a clear methodological systemisation, systematic reviews are transparent and reproducible and are thus based on clearly defensible criteria rather than ad hoc selection or researcher bias (Berrang-Ford et al., 2011). Such systematic approaches have been developed within social sciences (Waddington et al., 2012) and are applied predominantly in health sciences (Berrang-Ford et al., 2011). This review closely follows the methods as applied by Berrang-Ford et al. (2011).

Understanding of the different drivers of migration is complex and different drivers of migration are often addressed or identified in separate research articles and research projects. The method applied in this review focuses on identifying and listing determinants influencing migration in a small island setting. The following search syntax was used in the databases of Web of Knowledge on January 15, 2015: (Migration* OR migrant*) AND (“small island” OR “low lying island” OR (island AND (household OR person OR people))). The search syntax did not include any terms related to environmental change, climate change, or sea-level rise as the study focuses on all factors potentially influencing migration behaviour. The term “household”, “people”, or “person” was added to the search term in combination with “island” to restrict papers on human population and migration (in contrast to biological or genetic papers).

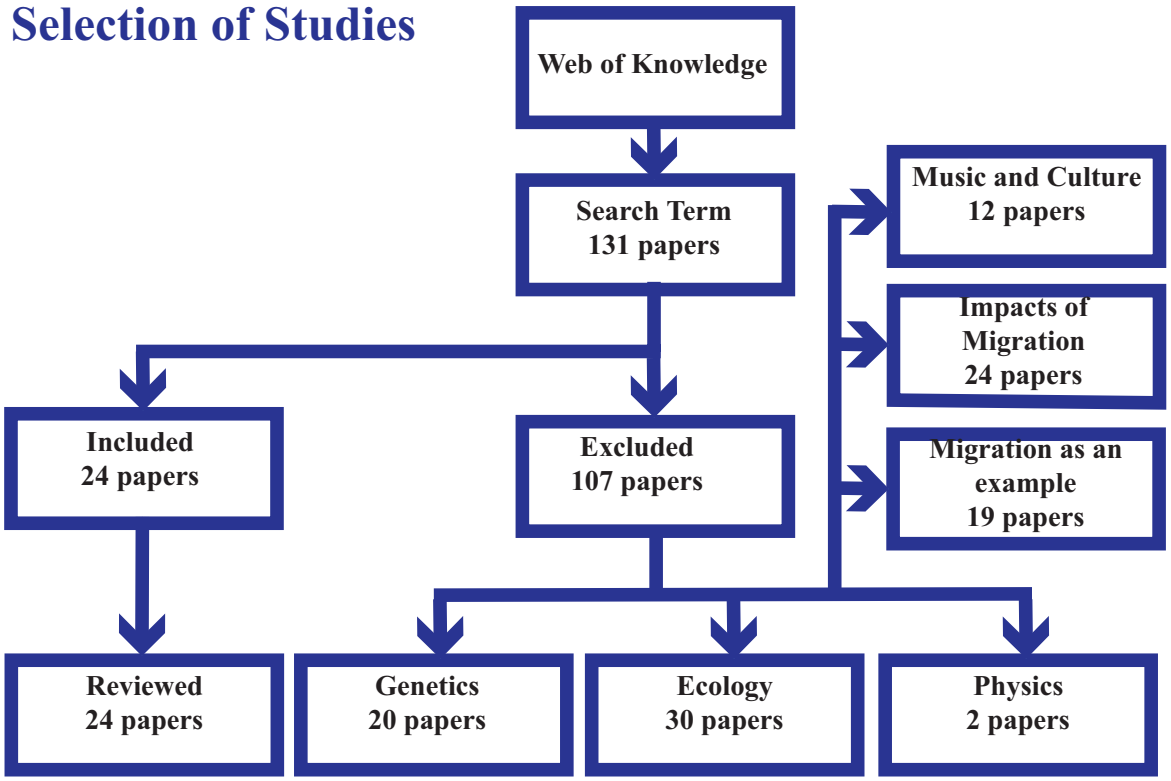

Figure 3.1 Selection of papers for analysis in the review.

The search yielded 131 hits (see Figure 3.1). These results were scanned and irrelevant papers were excluded. The criterion for selection for full review is that the paper contains explicit descriptions of migration decision-making or descriptions of determinants for migration. Fifty-two papers were removed from the database because they were of a genetic (20), ecological (30), or physical (2) nature. Another 12 papers were removed because they dealt with historic descriptions, music, or culture. Twenty-four papers dealt with impacts of migration flows, such as the economic impact of remittances, or the economic and social impacts of the brain drain due to migration. These papers however, did not identify determinants of migration and where thus also removed. Another 19 papers used migration as an example in either theoretical papers on potential impacts of environmental degradation or discussions about identity and were removed from the database. Twenty-four papers were selected (see Appendix A). These papers were entered into an excel database and organised according to publication details, the location of the research, the methods used, size of the research sample, and determinants studied (see Table 3.1).

Table 3.1 Procedure of systematic literature review.

Topic	Migration and small islands
Research questions	(1) What determinants are important in migration behaviour? (2) Where was the research undertaken? (3) What methods were used?
Keywords	(Migration* OR migrant*) AND ("small island" OR "low lying island" OR (island AND (household OR person OR people))).
Databases	Web of Knowledge
Number of selected papers	24
Categories of papers	Full reference details, authors, year, journal
Categories of location	Country/region
Categories of methods	Which quantitative approach (questionnaires, environmental data), which qualitative approach (interviews, content and text analysis, case studies, observations, and focus groups), mixed approach, or other. Number of participants (N).
Categories for subjects	Seasonality, type of migration (urban vs rural)
Categories of response variables	What determinants of migration were measured?

3.4 Description of papers

The papers were published between 1993 and 2014. Two papers were published in 1993, one in 2000, two in 2004, and the remaining 19 in 2008 or later. Fifteen papers focused on the South Pacific region, three in the Indian ocean, two on the Caribbean, one on an island in Ireland, one on the Canary islands, Spain, one a comparative paper between the Pacific region and the Caribbean, and lastly a global analysis paper. Nine papers took a quantitative approach, with methods ranging from using large datasets such as the census or household questionnaires; 13 papers used a qualitative approach using techniques such as focus group discussions or semi-structured interviews; one paper used a wide range of methods, including census and environmental datasets and combined these with semi-structured household interviews; lastly one paper identified determinants based on reviews and fieldwork observations. Four papers focused specifically on return migrants, two on migration of health professionals, one on temporary migration, three on both temporary and permanent migration, and the remaining 14 on permanent migration.

3.5 Description of determinants

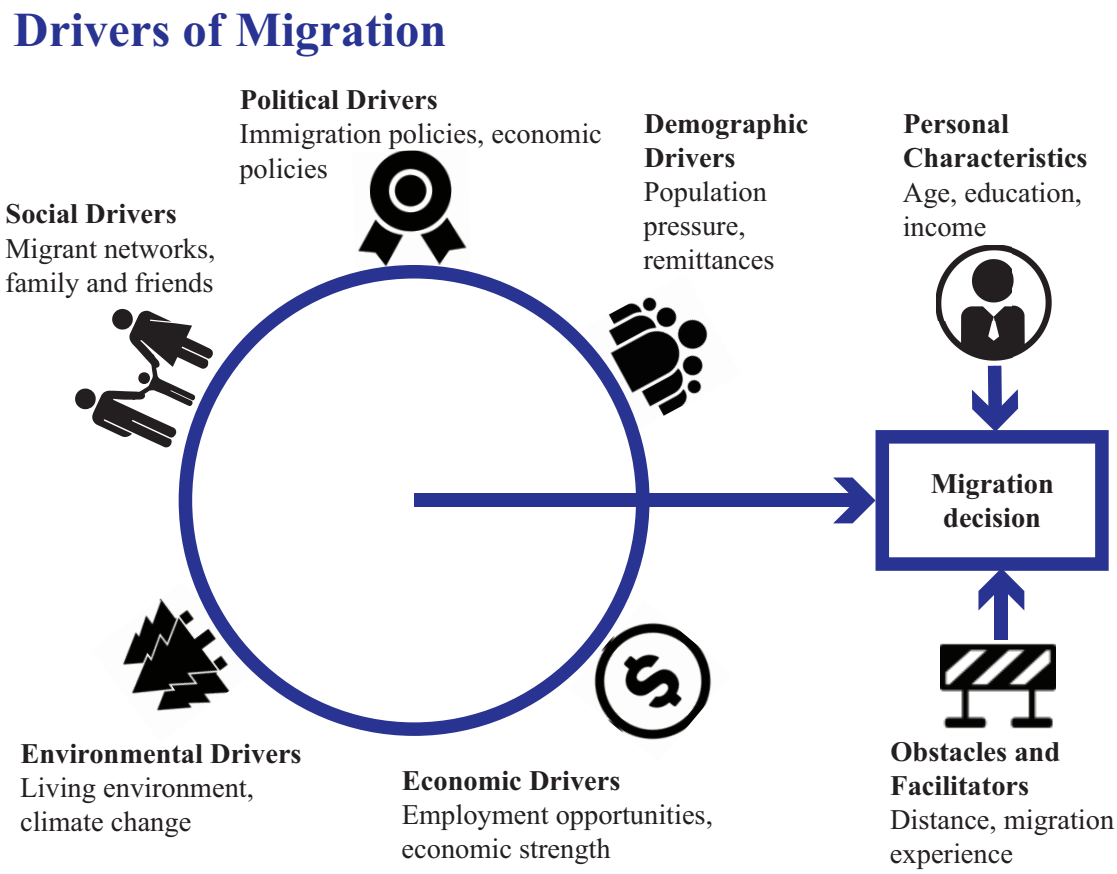

Figure 3.2 Drivers of migration (adapted from Black et al., 2011a).

To group the determinants of migration identified in the systematic literature review the theoretical framework of Black et al. (2011a) was used (see Figure 3.2). The framework 'Drivers of Migration' is an effort to provide an integrative view of demographic processes and environmental stresses and aims to provide an encompassing range of drivers that might affect the magnitude, direction, and frequency of migration movements. The framework has four components: (1) A distinction between types of migration (e.g. internal, international, temporary, and permanent migration), (2) identification of five families of drivers of migration, (3) incorporation of agency on how drivers translate into outcomes, and (4) the incorporation of environmental change as a direct influence on migration, and also as an indirect influence through changes to the other four drivers. The five families of drivers identified by Black et al. (2011a) are: (1) demographic, (2) economic, (3) social, (4) political, and (5) environmental drivers (Figure 3.2). In addition personal and household characteristics and intervening obstacles and facilitators can be identified. The five families of drivers are closely intertwined and should not be considered in isolation. A combination of drivers together leads to a migration decision and the environment influences these drivers. Hence, this framework is valuable for considering migration in small

islands, as it explicitly introduces environmental change as a factor in migration decision-making, while taking into consideration its socio-economic setting. The determinants identified in the systematic review were grouped according to these families of drivers (see Table 3.2 and Figure 3.3). Together, the determinants provide an overview of the drivers of migration in small island settings.

Table 3.2 Overview of determinants of migration identified in the systematic literature review. The number of papers indicate the number of research articles that have identified a determinant. These numbers are not measures of relative importance, but illustrate the spread and focus of research on migration in small island settings.

Categories (Total determinant count)	**Determinants**	**Methods used**	**Number of papers**
Personal and household characteristics (46)	Gender	Both	3
	Receiving remittances	Both	5
	Income	Both	3
	Job/unemployment	Both	4
	Land or business ownership	Quantitative	2
	Age	Both	6
	Marriage	Both	4
	Identity	Qualitative	5
	Education	Both	8
	Health	Both	2
	Children	Qualitative	3
	Ethnicity	Qualitative	1
Intervening obstacles and facilitators (14)	Distance	Quantitative	1
	Migrant network	Both	7
	Costs of migration	Qualitative	1
	Scholarship obligations	Qualitative	1
	Migration experience	Qualitative	4
Demographic (8)	Remittance community	Qualitative	1
	Population density/pressure	Both	3
	Life expectancy	Quantitative	1
	Population dynamics (growth, birth rate, death rate, infant mortality rate, rate of migration)	Quantitative	1
	Size of country	Quantitative	1
	Literacy rate	Quantitative	1
Economic (19)	Employment opportunities	Both	17
	Size of economy	Both	2
Social (27)	Culture of migration	Qualitative	3

	Lifestyle	Qualitative	3
	Being with family and friends	Qualitative	5
	Social status	Qualitative	1
	Sense of belonging to community	Qualitative	4
	Opportunities in improving quality of life	Qualitative	4
	Retirement	Qualitative	2
	Better healthcare	Qualitative	4
	Feeling secure	Qualitative	1
Political (7)	Immigration policies	Qualitative	2
	Political unrest	Qualitative	2
	Political dependency	Quantitative	1
	Economic policies	Qualitative	1
	Environmental policies	Qualitative	1
Environmental (13)	Climate change	Qualitative	3
	Quality of living environment	Qualitative	3
	(Degradation of) soil and water quality	Qualitative	2
	Disaster	Qualitative	3
	Degradation of environment	Qualitative	1
	Weather	Qualitative	1

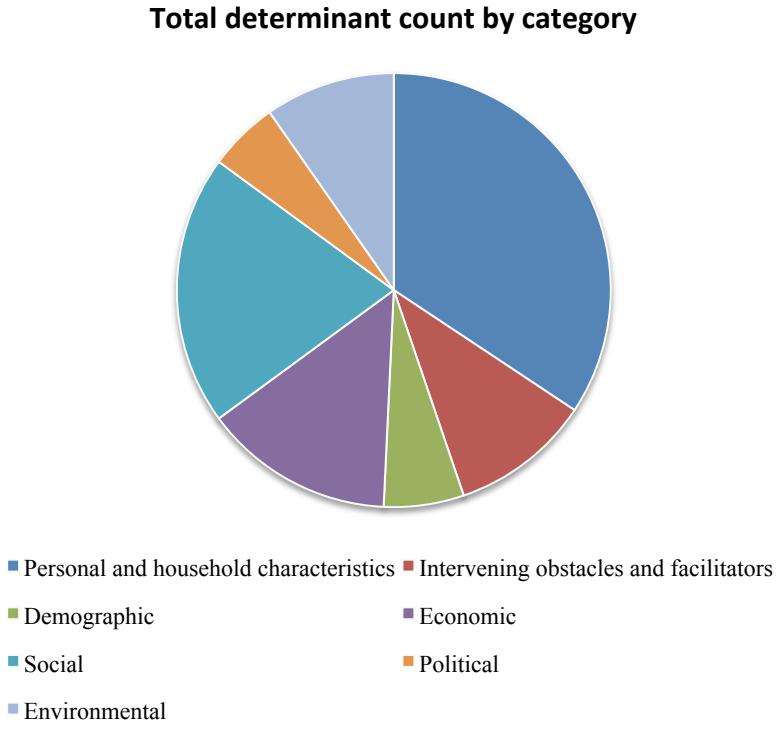

Figure 3.3 Total determinant count by category (sum of the determinants * number of papers).

First personal and household characteristics and intervening obstacles and facilitators of migration will be discussed followed by the five drivers of migration: demographic, economic, social, political, and environmental drivers.

3.5.1 Personal and household characteristics

The relation between personal characteristics such as age, marriage, having children, income, employment, health, and level of education and migration are widely studied in migration analyses (e.g. Antolin and Bover, 1997; Brettel and Hollifield, 2000; Grigg, 1977) and are also found to be influential in small island settings. One paper explicitly studied the effect of ethnicity and found that ethnical background is important in migration decisions (Brown and Leeves, 2010). Two papers focused explicitly on the role of health workers in migration dynamics and found that there is a difference in migration dynamics for different occupations (Brown and Connell, 2006; Connell, 2014). Differences in migration behaviour between genders were discussed in three papers (Chandra, 2004; Guan and McElroy, 2012; Sofer, 1993). Only two papers focused on the effect of ownership. Ownership of land or business at the place of origin is a limiting factor to migration (Brown and Connell, 2006; Shen and Gemenne, 2011).

Especially in the Pacific and Caribbean remittances play a large role in migration dynamics (Brown et al., 2014; Brown and Connell, 2006; Brown and Leeves, 2010; Connell and Conway, 2000; Leeves, 2009). The role of remittances in enabling or hindering migration is however subject to discussion. On the one hand remittances are enabling migrants due to increased financial opportunities, removing barriers for better education and costs of migration; on the other hand financial pressure and lifestyle can be improved at the place of origin. Lastly, five papers mentioned the effect of self-identity or self-image (Burholt et al., 2013; Connell, 2008; Maron and Connell, 2008; Mortreux and Barnett, 2009; Wilson, 2013). These factors were raised by respondents in qualitative interviews and relate to, for example, a strong sense of belonging, lifestyle, and culture. These can affect migration in different ways. A person who views him or herself as adventurous and internationally oriented is more likely to migrate compared to an individual with a strong attachment to their community.

3.5.2 Intervening obstacles and facilitators

Migrant networks are the most widely studied intervening obstacle and facilitator. In the South Pacific there are extensive established migrant networks. These networks are most developed with New Zealand and Australia. These networks ensure that potential migrants already have a cultural bond with the place of destination and often already have friends and family living at the

place of destination: such networks can thus help overcome initial migration difficulties (Birk and Rasmussen, 2014; Connell, 2008; Fog Olwig, 2012; Leeves, 2009; Locke, 2009; Shen and Gemenne, 2011; Wilson, 2013). Only one paper by Sofer (1993) identified distance as a significant factor. Potential costs of migration and scholarship obligations were each mentioned once in the papers (Birk and Rasmussen, 2014; Maron and Connell, 2008). Prior experience of migration was also considered important (Fog Olwig, 2012).

3.5.3 Demographic drivers

Most of the demographic attributes identified originate from one paper looking at small island states and their outmigration rates (Guan and McElroy, 2012). This paper looked at a range of demographic factors, including population dynamics such as infant mortality rate, birth rates, death rates, life expectancy, literacy rates, and the size of the country and its population density and combined these with economic and personal factors to estimate migration flows from entire small island nations. In addition to this paper, two qualitative papers mentioned population pressure as a factor in migration (Connell, 2008; Wilson, 2013). One paper focused on remittances and described a demographic characteristic called a 'remittance community', a community that depends on remittances and where the benefits of remittances are shared (Connell and Conway, 2000).

3.5.4 Economic drivers

The most mentioned factors identified in the review are (perceived) employment opportunities at the potential destination of migration, or the lack of opportunities at place of residence. Seventeen papers mentioned this factor, supported by both qualitative and quantitative studies. In addition to employment opportunities, the size of the economy at origin and destination was reported in two papers to be an indicator of larger migration flows (Alemán and León, 2010; Guan and McElroy, 2012).

3.5.5 Social drivers

Social factors were studied by qualitative surveys, interviews, or focus group discussions. Three papers mention that high rates of migration of previous generations can result in a culture of migration. Migration behaviour can become the norm in communities as migration becomes an indicator for a successful career and life, resulting in pressure from the community to migrate (Birk and Rasmussen, 2014; Connell, 2008, 2014). In contrast, papers also mention the sense of belonging to a community as an important factor to stay (Birk and Rasmussen, 2014; Maron and

Connell, 2008; Mortreux and Barnett, 2009; Wilson, 2013). Providing a similar contrast, three papers mention lifestyle as a reason to stay at the place of origin (Burholt et al., 2013; Connell, 2008; Mortreux and Barnett, 2009) and four papers mention how people expect migration to improve their quality of life (Birk and Rasmussen, 2014; Burholt et al., 2013; Mortreux and Barnett, 2009; Shen and Gemenne, 2011). Five papers explicitly mentioned that family and friends are a reason to stay or to migrate (Birk and Rasmussen, 2014; Florence et al., 2010; Mortreux and Barnett, 2009; Shen and Binns, 2012; Shen and Gemenne, 2011). One paper mentioned that social status can influence migration behaviour, as in certain communities the social standing of an individual might be influenced by prior migration behaviour (Thomas-Hope, 1993). Other reasons include a feeling of security (Burholt et al., 2013) and retirement (Burholt et al., 2013; Maron and Connell, 2008). Better healthcare can also be a driver to leave small islands (Birk and Rasmussen, 2014; Connell, 2014; Florence et al., 2010; Locke, 2009; Reenberg et al., 2008). Most social factors described are contrasting in nature even within small island communities, for example family and friends can be a reason to stay, or to leave to live with close family overseas.

3.5.6 Political drivers

Immigration policies of receiving countries are important in influencing migration streams. The political and cultural relations between New Zealand and Australia and small island states in the Pacific are particularly close. The *Māori* culture in New Zealand is closely related to the Polynesian culture in the Pacific (Shen and Binns, 2012). There is a long history of migration of Pacific islanders to New Zealand and there were significant periods of migration in recent history during the 1960s and 1970s. As an effect, the immigration policies of New Zealand play a large role in migration streams (Shen and Binns, 2012). Similar relations exist between Spain and the Canary Islands (Alemán and León, 2010). Further, political unrest can increase the size of migration flows, as was shown in analyses in Fiji and the Solomon Islands (Chandra, 2004; Reenberg et al., 2008). Political dependency on large nations was also shown to influence the size of migration streams from small island states (Guan and McElroy, 2012). Lastly, the only paper included in the systematic literature review on the Maldives discussed the effect of economic and environmental policies on internal migration patterns in the Maldives (Kothari, 2014). The national government argues that it is economically unsustainable to provide adequate services and resources to the dispersed population on over 200 populated islands, compared to focusing development on a more limited number of key islands. These plans gain further importance with environmental change, as the government argues it would be unsustainable to provide adequate protection on all currently inhabited islands.

3.5.7 Environmental drivers

The living environment is mentioned often as a driver of migration. On many islands the general living conditions including housing, sanitary facilities, and solid waste disposal leave much to be desired (Birk and Rasmussen, 2014; Locke, 2009; Shen and Binns, 2012). Decreasing water and soil quality, and general environmental degradation can further decrease the quality of the living environment (Birk and Rasmussen, 2014; Locke, 2009; Shen and Gemenne, 2011). The quality of the living environment influences migration decisions. Natural disasters have been shown to influence rates of migration in the past (Birk and Rasmussen, 2014; Locke, 2009; Shen and Gemenne, 2011). Weather was mentioned in one paper as a reason not to migrate (Alemán and León, 2010).

Climate change was mentioned in three papers, which all concern migrations from Tuvalu. The first paper concluded that people do not consider climate change as a factor in migration decisions, nor expect climate change to be a factor in the future (Mortreux and Barnett, 2009). In contrast, the second paper argues that migration due to climate change and environmental degradation is already happening in Tuvalu (Locke, 2009). However, although this paper is insightful in its concepts, its main conclusions on the effect of climate change on migration are speculative rather than supported by data. In contrast, Shen and Gemenne (2011) shows that many people, who already migrated from Tuvalu to New Zealand, do mention climate change (and implicitly environmental factors) as a driver of their migration decisions.

3.6 Discussion and conclusions

Determining the human dimensions of environmental change requires a thorough understanding of the setting in which such changes occur. Detailed assessment of migration processes and its potential environmental contribution is necessary to understand how migration flows will develop in the future. It is important to recognise that environmental change is not the sole cause of migration, but rather it will amplify or alter existing demographic trends (Black et al., 2011a). This review provides an overview of existing research on migration in a small island setting and identifies a variety of determinants for each of the five drivers of migration, personal characteristics, and obstacles and facilitators using the framework ‘Drivers of Migration’ by Black et al. (2011a) in order to provide a better baseline of understanding of migration in small island settings.

This review shows that personal characteristics such as age, marital status, income, and level of education are indicators of migration in small island settings. Young, high-educated people are more likely to migrate both nationally and internationally. This finding is consistent with classic

migration theories such as Ravenstein (Grigg, 1977) and Lee (1966), and the theoretical framework of Black et al. (2011a). The review identified a range of such factors for each of the five drivers. Perceived employment opportunities at the place of destination, or lack of economic opportunities at the place of residence was most widely studied and mentioned by 71 per cent of papers as an important factor in migration decision-making. As shown in Table 3.2, many of the determinants have only been identified by small number of papers. Perceived employment opportunities, migrant networks, age, remittances, education, culture, family, and identity are the only other factors mentioned by five or more papers. Twenty-three out of 45 determinants have only been identified by one or two papers. Further, the geographic spread of the papers is limited, as the main body of literature focuses on migration in the South Pacific. There are, for example, no published papers specifically about migration characteristics in the Maldives or the Seychelles included in the review. Further, only three papers focused on migration and climate change.

Small island states generally have small economies with limited opportunities and like in many other developing nations, economic development focuses around the capital cities. For example, in the Maldives, the capital island of Malé is the centre of economic development, services, and political power and it has grown to a population of about 127,079 on an island of 1.98 km^2 in 2014, 32 per cent of the total population, resulting in a population density of 64,148 people per km^2 (National Bureau of Statistics, 2015). The capital city of Malé dominates national migration flows and migrants often move to the capital for economic and educational reasons (Speelman and Nicholls, submitted) (Chapter 4). The capital of Tuvalu, Funafuti, has a population of 6,194 in 2012 (UNFPA, 2012), 57 per cent of the total population. In Kiribati the capital city South Tarawa experiences similar strong population and development pressures as Malé in the Maldives, with a population of 50,182 in 2010, 52% of the countries' population (e.g. Elrick-Barr et al., 2015). Due to the small size of these capital islands (being atolls), even relatively low population levels result in high pressure on land availability and can affect the quality of life. In Kiribati and the Maldives these pressures have resulted in land reclamation to increase the urban area for the capital (around Malé and the creation of Hulhumalé and the airport). In other small island states, such as Vanuatu or the Seychelles, the capital islands experience similar urbanisation, but as the capital islands are larger (non-atolls) the pressure on land availability and related influence on quality of life is smaller. The capitals of these small island states all have an important economic function and attract migrants from more rural, less populated islands. However, contrary to the example of the Maldives, many other small island states have high rates of international migration and have already developed strong international migrant and remittance networks.

Strong migration networks and migration experience facilitate migration and are particularly important determinants for international migration. As large numbers of islanders from South

Pacific islands have moved to New Zealand and Australia large migrant networks have developed. In 2006, 269,974 residents of New Zealand (or 6 per cent of the total NZ population) identified themselves as Pacific islanders (Statistics New Zealand, 2006). These networks ensure that potential migrants already have a cultural bond with the place of destination and friend/family members who are resident. Such networks help overcome initial migration difficulties (Birk and Rasmussen, 2014; Connell, 2008; Fog Olwig, 2012; Leeves, 2009; Locke, 2009; Shen and Gemenne, 2011; Wilson, 2013). These international migration flows often result in large remittances to the countries of origin. Especially in countries where there is a strong remittance economy, most notably in the Pacific (see Table 3.3), remittances also play an important role in migration dynamics (Brown and Connell, 2006; Brown et al., 2014; Brown and Leeves, 2010; Connell and Conway, 2000; Leeves, 2009). In contrast to migration networks, remittances can play a contrasting role in migration decision-making. Whereas remittances can provide the financial means to remove barriers to migration, these financial means can also be used to improve the quality of life at the place of residence. There are differences in the importance of remittances between Pacific nations depending on the share of population that has migrated internationally (Connell and Brown, 2005). For example, Tonga received an estimated USD114 million in 2014, about 25% of the country's GDP, whereas in Vanuatu remittances account for about 3% of GDP in 2012 (World Bank, 2015). In the Maldives remittances only account for 0.20% of GDP in 2010 (Ratha et al., 2011), as international migrant networks are minor. The Maldives receives significant numbers of guest workers itself who are sending remittances themselves. Future development of such networks could lead to a significant increase in international migration.

Remittances and development of migration networks and the geography of capital cities mentioned above are examples of differing processes influencing migration dynamics between island states. By contrast, the influence of economic and educational opportunities is similar between the islands.

Table 3.3 Selected small island nations and received remittances in 2014 (World Bank, 2015).

Country	Basin	Remittances (Million USD)	Share of economy (%)
Tonga	Pacific	114	24.46
Comoros	Indian	121	20.2
Samoa	Pacific	140	17.46
Marshall Islands	Pacific	22	11.52
Tuvalu	Pacific	4	10.53
Cape Verde	Atlantic	188	9.91
Kiribati	Pacific	13	7.69
Saint Kitts and Nevis	Caribbean	52	6.79
Fiji	Pacific	209	5.42
Grenada	Caribbean	31	3.71
Vanuatu	Pacific	24	2.9
Saint Lucia	Caribbean	30	2.25
Mauritius	Indian	267	2.24
Barbados	Caribbean	87	2.06
Solomon Islands	Pacific	17	1.55
Seychelles	Indian	15	1.04
Maldives	Indian	3	0.13

This systematic review demonstrates that migration in small island settings is a complex process and that the drivers of migration are not well understood for many small island states, despite the high profile of small island states and migration in the climate change debate (e.g. McLeman, 2011; Burkett, 2011; Kelman, 2015). There is a risk and even likelihood that in the discourse about impacts of climate change on small island states that any migrants from small island states will be classed as 'climate refugees', especially if there is a future increase of migration flows. It is however, important to consider that such flows are not influenced by climate change alone, but that decisions of individuals are rather embedded in existing processes of migration. To understand how migration flows will develop in the future and to understand its environmental component, it is important to improve the empirical foundation of all five drivers of migration. Future research should address this gap and should focus both on the socio-economic *and* the potential environmental components of migration in small island states. Such understanding helps to better understand future (migration) pathways, potential impacts of climate change on migration, and hence to develop better-informed policies on these issues.

Chapter 4 Migration flows in a small island setting: A case study of the Maldives and its wider implications

4.1 Abstract

Migration is often mentioned as a major potential impact of climate change for small island settings, especially on low-lying atolls. Understanding future migration flows, including the potential role of environmental factors, requires an interdisciplinary approach and a thorough understanding of migration flows and behaviour. Despite the high profile of low-lying islands in the debate on climate change and its potential effects on coastal societies, there have only been limited efforts to investigate contemporary migration on low-lying islands. Based on demographic, socio-economic, and environmental datasets, this paper analyses migration flows between islands in one low-lying island nation -- the Republic of Maldives from 2000 to 2006. Migration is a significant process and the capital island Malé and its environs ('Greater Malé') dominates national migration flows with a large net influx of migrants. This is in contrast to the numerous islands with relatively low populations, which are experiencing high rates of out-migration and declining populations. There is a large differentiation of levels of development, vulnerability, and population size and structure between islands. These are helpful indicators in analysing migration: higher socio-economic, and physical vulnerabilities indicate higher rates of migration. These trends are likely to continue even without environmental change. As significant land claim is occurring in Greater Malé (and taller buildings are planned), land availability is not a constraint on further population growth, and it is likely that Greater Malé will continue to have a strong pull factor for potential migrants for decades to come. These trends are reinforced by government policy with development being concentrated on a few islands via the "population consolidation" and "Safer Island" policy programmes. Climate change and sea-level rise can potentially exacerbate these existing migration processes, leading to increased out-migration from more vulnerable islands to better protected and wealthier islands. The example of the Maldives shows that future studies linking climate change and migration should carefully consider socio-economic settings and developments, even where the potential impacts of climate change are high.

Keywords: Migration; Census Analysis; Small Islands; Climate Change; Poisson Regression

4.2 Introduction

The threats of climate change and sea-level rise to small islands are well established (Nurse et al., 2014). Related drivers of risk include sea-level rise, storms, increasing air and sea surface temperatures, ocean acidification, and changing rainfall patterns. These are in turn likely to impact the ecosystems on which people living on small islands depend, including coastal erosion and inundation, salinisation of fresh water lenses, coral bleaching, changing abundance and distribution of fish species, and agriculture. Further impacts on various key economic sectors such as tourism and ports/shipping could be significant. Global analyses suggest that island regions will experience the largest relative increase in flood risk due to sea-level rise in the coming century (Nicholls et al., 1999; Nicholls, 2004), and low-lying atoll regions appear to be consistently vulnerable across a wide range of scenarios (Nicholls and Tol, 2006). These studies all reinforced the high vulnerability of small island states and especially low-lying atoll islands.

The first papers and Intergovernmental Panel on Climate Change (IPCC) assessment on climate change and its impacts on small islands in the early 1990s already suggested that sea-level rise could lead to total inundation of small low-lying islands (especially coral atolls) and mentioned migration and ecological refugees as the major potential impact of climate change for small island states (Lewis, 1990b; Pernetta, 1989, 1992; Tegart et al., 1990). This view has been reiterated in all subsequent IPCC assessments (Bijlsma et al., 1996; McCarthy et al., 2001; Mimura et al., 2007; Nurse et al., 2014; Watson et al., 1997; Zinyowera et al., 1995). More recently, the potential high costs of adaptation to sea-level rise and climate change for islands was suggested as a driver of migration (Biermann and Boas, 2010; Gemenne, 2011; Nicholls et al., 2011).

However, migration is a complex process and linkages operate through a large variety of drivers (e.g. Black et al., 2011a). Understanding future migration flows, including the potential role of the environment, requires an interdisciplinary approach, as both the linkages between ecological and social systems, as well as individual or household decision-making processes must be considered. It is therefore fundamental to consider existing migration flows and contemporary migration behaviour when analysing potential future changes in migration including the potential effects of climate change. Despite the high profile of low-lying islands in the debate on impacts of climate change and sea-level rise and its potential effects on coastal societies, there have only been limited efforts to describe and analyse empirical migration behaviour on small islands.

This paper addresses this gap using the Maldives. It analyses raw census data from 2006 and combines the results with socio-economic and physical vulnerability indices to describe migration flows in the Maldives on the level of 376 island communities within this island nation. It takes an exploratory approach and analyses three increasingly complex statistical models of internal flows

of permanent migration that start with gravity models, and add socio-economic and then physical vulnerability factors.

The paper is structured as follows. First the Maldives is introduced and general population dynamics and migrant characteristics will be described. Second, datasets and methods will be described; and the results of Poisson regression analyses will be presented. This is followed by a discussion and conclusion.

4.3 Case study: The Maldives

This section describes general population structure and developments in the Maldives over the past three decades. Further, migrant characteristics are described based on 2006 census data.

The Republic of Maldives, at 298 sq km, is the sixth-smallest sovereign state in terms of land area. The land is divided into 1,192 coral islands, of which 96% are less than 1 sq km in area. Shallow lagoons enclosed by coral reefs surround the islands with an average height of only 1.6 meters. The Maldives is a Sunni Muslim society and its constitution is based on sariatu, the Maldivian interpretation of the traditional sharia. In 2006, 193 islands were inhabited and 91 islands had been developed as tourist resorts. The country had a population of 298,968 in 2006, resulting in a highly densely populated nation with 1,003 people/km^2. Preliminary results of the 2014 census report that the population has increased to 399,939 (National Bureau of Statistics, 2015), including an estimated 58,683 guest workers. However, one estimate for guest workers in 2010 was 110,000 people (U.S. Department of State, 2010) and the numbers seem still to be growing, so the 2014 census may well be an underestimate of total population including guest workers. The Maldives consists of 19 administrative regions called Atoll Districts, roughly corresponding to its natural groups of atolls, and an administrative region of the capital city Malé (see Figure 4.1). The urban area of the capital city of Malé (Greater Malé) consists of several additional islands in the vicinity of the capital island, including the artificial island Hulhumalé, the airport island Hulhulé, and Villingili.

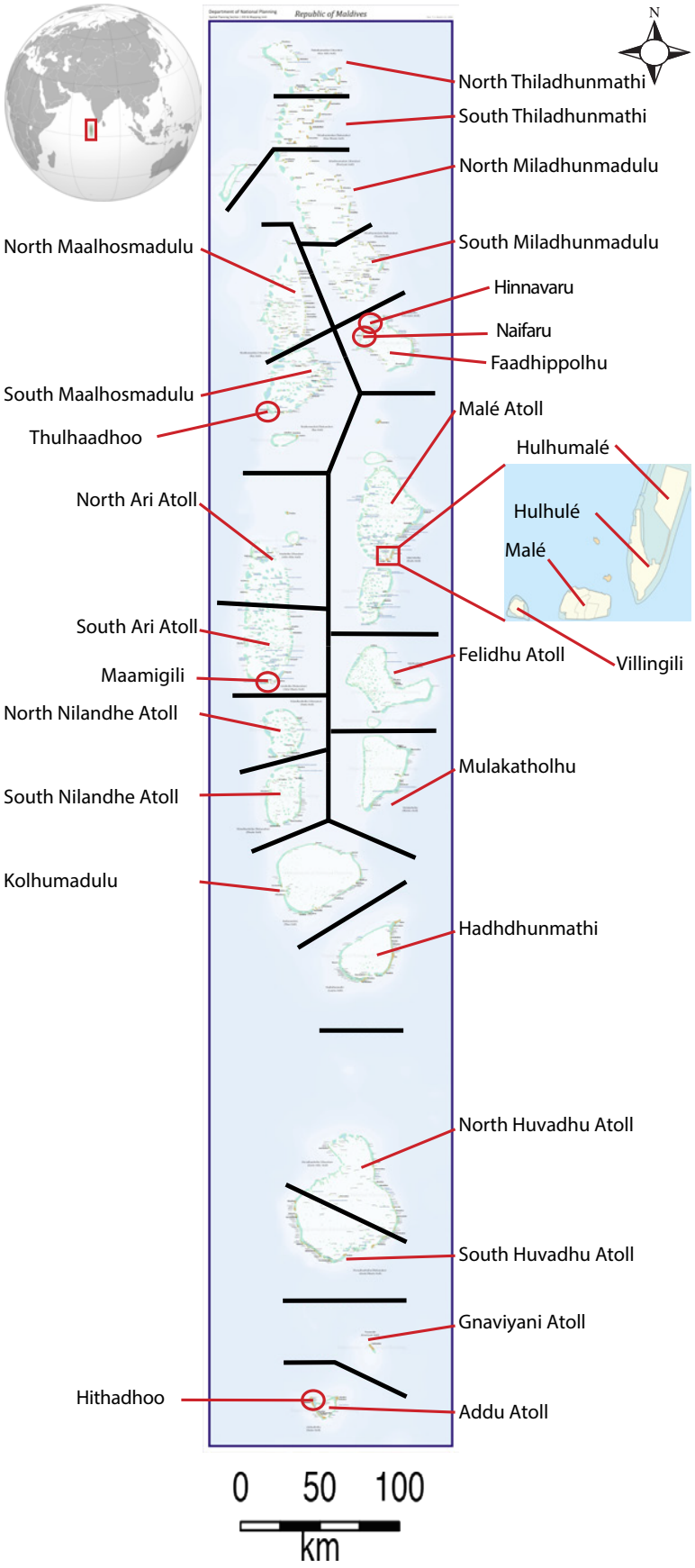

Figure 4.1 Map of the Maldives. The regional centres Maamigili, Thinadhoo, Hithadhoo, Naifaru, Thulhaadhoo, and Hinnavaru were undertaking or have completed land reclamation projects in 2006 to provide the necessary space, as in Hulhumalé.

4.3.1 Population growth and fertility

Since 1900, the Maldives has experienced changing rates of population growth. Whereas in the first half of the 20th century population remained relatively stable, the population grew rapidly during the second half of the century due to changes in both mortality and birth rates. Life expectancy at birth for men increased from 51 to 71.6 years from 1980 to 2006, and for women from 49 to 72.6 years. Between the 1990s and 2006 the growth rates started to decline, mostly due to a drop in fertility rates of about 6.4 per woman in the 1990s to 2.2 in 2006. The number of households increased from 41,012 in 2000 to 46,194 in 2006, with 85 per cent of the increase in Greater Malé. Maldivians have large extended families that often share living quarters, explaining the high average household size of 6.5 people. The share of female-headed households in the Maldives is 44% in 2006, relatively high compared to other countries. According to the Maldivian Bureau of Statistics, this is most likely due to males having migrated for employment purposes. This is supported by the census data as only 4% of the female population mentioned they migrated for employment purposes, versus 30% of the male population. It also reflects the high rate of divorce in the Maldives and widowed female-headed households, each accounting for roughly 5% of the female-headed households. The Maldives has a young population, with a mean age of 25.6 years and 25% of the population 12 or younger and 75% of the population being 36 or younger in 2006. Recent declines in fertility suggest that over time the population will age and become more uniformly distributed with age.

4.3.2 Population distribution and land reclamation

The population of the Maldives is highly dispersed. Only 10 of 193 inhabited islands have a population of over 2500 in 2006. The centre of population is the capital island Malé, where the population increased from 45,874 in 1985 to 92,555 in 2006. (Including the surrounding islands of Villingili and Hulhumalé the population of Greater Malé is 103,693 in 2006 (see Figure 4.2). In the rest of the country the population grew from 134,212 to 195,175 in the same period. Hence, over a third of the population lives in Greater Malé in 2006. First estimates of the census indicate the population on Malé has increased to 127,079 people in 2014, including guest workers, on an island of 1.98 km^2, resulting in a population density of 64,148 people per km^2 (National Bureau of Statistics, 2015). Further, the population of Hulhumalé has increased to 15,769, and together with Villingili, the population of “Greater Malé” increased to 153,379, about 38% of the Maldivian population. The sharp increase in population growth can be attributed to the newly included estimates of guest workers in the 2014 census.

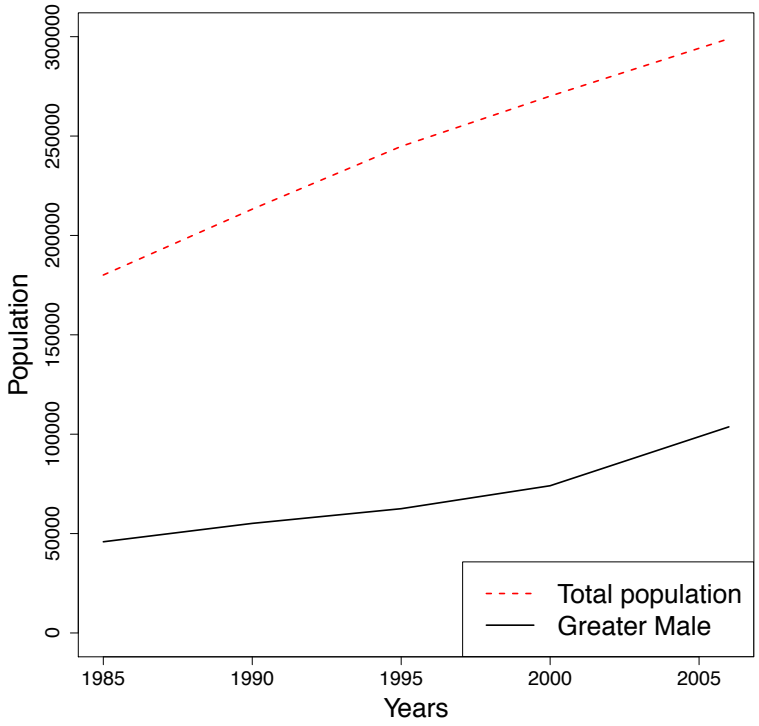

Figure 4.2 Population trends in the Maldives and Greater Malé: 1985 to 2006. This data excludes guest workers.

Government policy influences migration. The national population consolidation programme focuses on developing stronger regional centres and reducing the dispersion of population over the archipelago, and the associated costs of development (Ministry of Planning and National Development, 2004). The government argues that up to 4-5 times the investment is required, compared to other developing countries, to increase the level of services to the desired levels with the present population distribution. Hence, the Maldives will be more competitive economically with development focused at regional centres (Ministry of Planning and National Development, 2004). In line with these developments, the regional centres Maamigili, Thinadhoo, Hithadhoo, Naifaru, Thulhaadhoo, and Hinnavaru (see Figure 4.1) were undertaking or have completed land reclamation projects to provide the necessary space in 2006, as in Hulhumalé (Ministry of Environment, Energy and Water, 2007). Between 2000 and 2006, 3356 people had migrated following the population consolidation programme. Three islands were abandoned, as people from the islands Berinmadhoo, Firubaidhoo, and Maakadoodhoo were relocated to other islands in their Atoll District. Additionally, the government proposes to increase efforts to promote internal migration to growth centres by means of increasing standards of services such as schools, hospitals, and shops; conduct advocacy for the population consolidation programme; provide long-term solutions such as reclamation and resettlement; and develop employment and income generating activities in specified growth centres (Ministry of Planning and National

Development, 2004). In addition, the government of the Maldives aims for a population policy where the fertility levels are near-replacement by 2020 by means of education and access to contraceptives to couples.

4.3.3 Migration

As the residual of the natural increase in population and actual population change has been small over the course of the last 100 years, the Maldivian Bureau of Statistics concludes that official net in- and out-migration of the Maldives has been negligible. In the census of 2006 <1% of the population stated that their place of birth was in a different country. These estimates however, do not include guest workers. Although the out-migration of Maldivians is low, significant movements of migrants between the islands is observed. In the 1985, 1995 and 2000 censuses, over 22%, 19% and 18% of the Maldivian population indicated that their place of birth was on a different island within the Maldives, respectively. However, in the 2006 census, 35% of the population had a different place of registration compared to their place of birth.

Roughly half of all internal migrants moved to Greater Malé. The population boom of Greater Malé since the 1980s also coincides with the development of the Maldives as a major tourism destination, including the development of an international airport and the development of resort islands near Malé. Initially, Malé island was expanded in size using land claim by pumping sand from a lagoon onto a seaward facing reef flat (Pernetta, 1992). Building heights also increased (currently limited to 12 stories), but taller buildings (to at least 20 stories) are planned. Due to continuing high population pressure and to account for future population growth and housing needs and to spur economic development around the capital island, the artificial island of Hulhumalé was created close by Malé in the 1990s and is at time of writing about 4 km^2 in size and is being expanded in size. The island is planned to house 60,000 people in 2020 and further expanded to 100,000 in the coming decades (Hulhumalé Developing Corporation, 2015). However, the island could house a population at higher densities than planned, resulting in a higher potential future population. Further a second runway is planned at the airport linked to further major reclamation, and there are proposals to link these islands by bridges and causeways. By means of these ambitious plans, the Maldives ensures that the capital city of Malé is able to continue growing in the decades to come. Furthermore, it shows the ambition of the government of the Maldives to focus its main investments and economic development around Malé.

4.3.4 Migrant characteristics

The 2006 census questionnaire includes several questions dealing with migration. A migrant is defined as a person who answered the question whether or not the person migrated with 'yes' and lives at their current usual residence since 2001, or later. The answer is cross-checked with the place of residence in 2001 and in 2006. Questions on the usual residence of the migrant and the place of residence in 2001 are used as an estimate of the place of origin and destination of each migrant. A total of 63710 people are identified as migrants, 21.3% of the total population.

Table 4.1 Migrant and general population statistics in 2006.

Variables	Mean migrants	σ migrants	Mean general population	σ general population
Age	23.88	13.08	25.64	17.53
Education	8.03	3.72	6.89	3.68
Hours worked	6.20	6.19	5.43	6.49
Sex (Male)	55.5%		50.07%	
Marital status (Married)	48.9%		59%	
Literacy (yes)	98.6%		93.8%	
Employed (yes)	54.4%		53.5%	
Source: Population and housing survey, 2006, by the National Bureau of Statistics, Department of National Planning				

Table 4.1 shows that migrants are relatively young and well educated. Also, they are less likely to be married and more likely to be employed and to work longer hours. In the 2006 census, self-reported reasons for internal migration are presented and are consistent with the findings of Black et al. (2011a): 79% of migrants indicate they moved because of educational, economic or social reasons. An additional significant reason for migration is the 2004 tsunami. The Maldives was severely hit with more than 82 confirmed deaths and 26 people missing, and damage and destruction on a nationwide scale (Hermann et al., 2006). The economic damage alone is estimated to account for roughly 62% of the Maldivian GDP (Ministry of Planning and National Development, 2005). According to the self-reported census data of 2006, almost 4000 people were still displaced due to the 2004 tsunami 18 months later. The population on the islands Kadholhudhoo, Madifushi, Gemendhoo, Vilufushi, were all (temporarily) displaced to other islands.

4.4 Data

The demographic data used in the previous sections and in the migration flow analysis is extracted from the raw 2006 census dataset of the Maldives and was provided by the Bureau of National Statistics of the Maldives. The census data covers demographic and socio-economic aspects of the Maldivian society. Although the first modern census was conducted in 1977, and at 5-year intervals from 1985-2000, earlier census datasets are only available in aggregated form and in summary reports, and are therefore not included in the analyses. The census of 2005 was delayed by one year due to the large impact of the 2004 tsunami.

In the analyses presented in the sections below, the census data is used to describe migration flows between islands and the associated characteristics of islands of origin and destination. Individual migrant and population characteristics are aggregated to 376 island level characteristics. Migration flows to and from each inhabited island in the Maldives are calculated. A total of 376 islands are included in the analysis, resulting in 141,000 possible migration flows between islands. This number is higher than the number of official inhabited islands as the raw census dataset includes all islands where people are officially registered, which also include resort islands and islands with industrial functions. Due to the high dispersion of population between islands in the Maldives, this results in a dataset with many low values for migration flows and a small number of high values. All variables included are summary statistics on island level for both the origin and destination of migration flows. The explanatory variables used in this research are included in Table 4.2. Population and distance variables are included, as well as social, economic, and demographic variables.

The latitude and longitude of each island was retrieved using a php script from the website of ISLES, a project of the government of the Maldives (ISLES project, http://isles.egov.mv/) and combined with the island codes as used in the 2000 and 2006 census. These were used to calculate the distance between all islands. A contiguity variable was added as a measure to account for people moving locally within their Atoll District. The Maldives Government defines specific economic and land use functions for each island such as, resort islands, airports, industry, solid waste disposal, residential and administrative. Hence, the islands were grouped according to their official category function, as different functions might attract different types of migrants.

Table 4.2 Definitions of explanatory variables by type. All variables are on the level of island communities.

	Variable name	Variable description
Demographic and geographic variables[a]	Population	Logged population size of both the origin and destination island
	Distance	Logged distance between the origin and destination island
	Contiguity	A contiguity variable with the value 1 if a migrant moved within an Atoll District and otherwise 0.
	Category	The official category of an island. 1 = Residential or administrative, 2 = Resort island, 3 = Industrial or other.
Socio-economic and demographic variables[a]	Age	Average age of island population
	Sex	Share of males of island population
	Marital status	Share of married island population
	Literacy	Share of literate island population
	Education	Average level of highest attained education. Education is defined as from 0 (no education) to 17 (MSc degree or above).
	Employment	Share of employed population
	Hours worked	Average amount of hours worked in the past two weeks
Physical vulnerability[b]	Tsunami impact	Tsunami impact ranging from 0 (low impact) to 1 (high impact)
	Beach erosion	Reported beach erosion ranging from 0 (no erosion) to 1 (strong erosion)
	Reef damages	Reported reef damages ranging from 0 (low damages) to 1 (high damages)
Primary needs[c]	Water index	Based on drinking water availability and safety, methods for cleaning the drinking water, and the source of drinking water.
	Food index	The food security index consists of experienced food crises, height for age, weight for age, and weight for height.
	Health index	The health index is based on the availability of personnel and medicines, presence of hospital on the island, and whether there is a hospital available within 2 hours travel.
Development[c]	Poverty index	Consists of measures of the share of the island population with an income less than Rf. 7.5, Rf. 10, and Rf. 15 per day.
	Employment index	Based on whether members in the household are working or looking for more work, aggregated to island level communities.
	Education index	Based on the number of pupils per teacher, the highest level of education offered on the island, and school services.
Services[c]	Consumer goods index	A measure consisting of whether there are more than 100 people per shop, and whether a household owns a sewing machine, washing machine, fan, and fridge.
	Communication index	This index is based on the availability of telephone landlines, mobile phones, television, radio, and national

		newspapers.
	Electricity index	Based electricity availability for >6 hours per day.
	Transport index	Based on the frequency of boats to Atoll District capitals and to Malé, harbour and reef difficulties, the availability of jetty's
Living environment[c]	Environment index	Based on reported erosion, bury or garbage dump in non-demarcated areas, cooking on wood, availability of toilets, and population density.
	Housing index	Based on the quality of houses and how often there are more than 5 people per room living in a house.
	Recreation index	A measure based on the availability of clubs, events, open space, and community activities.

Source: a) Population and housing survey, 2006, by the National Bureau of Statistics, Department of National Planning b) Maldives and Tsunami Impact Report, 2005, by the Department of Planning and National Development of the Republic of Maldives and the UNDP Maldives and c) Vulnerability and Poverty Assessment, 2004, by the Department of Planning and National Development of the Republic of Maldives and the UNDP Maldives

In addition to the census datasets, socio-economic and physical vulnerability indices are included in the analysis. These are derived from several vulnerability assessments carried out by the government of the Maldives and UNDP. The first measure included in this study is an analysis on the impacts of the 2004 tsunami performed by the commission of the Department of Planning and National Development of the Republic of Maldives and the UNDP Maldives (Hameed and Coeur-Bizot, 2005). The commission determined the impact of the tsunami on most islands of the Maldives. The scale is a measure from 1-5, where the islands coded with 1 represent the islands with the highest impact of the tsunami. Code 1 includes evacuations and requirement of temporary shelters, 2 population displacement and major damage to infrastructure, 3 substantial damage to houses and infrastructure, 4 limited damage, and 5 no flooding/damage. The tsunami impact assessment was carried out for the majority of islands, accounting for 82% of all migrant streams. To account for missing data in these measures, the impact of the tsunami on the remaining islands was estimated to be the mean of the impacts of the collected data of their respective Atoll Districts. Additionally, measures on reported erosion events and damages to reefs were included in the analysis from the Tsunami Impact Assessment (Hameed and Coeur-Bizot, 2005). All physical vulnerability variables were recoded from 0 (no impact) to 1 (very high impact). These variables were then summarised in one physical vulnerability measure *Physical Vulnerability* by summing the three variables.

The remaining data was extracted from the Vulnerability and Poverty Assessment (VPA) carried out in 2004 by the Department of Planning and National Development of the Republic of Maldives and the UNDP Maldives (Hameed and Coeur-Bizot, 2004). The VPA was conducted in 2004 and included household interviews and further in-depth interviews with a smaller number of

randomly selected individuals and were performed on most inhabited islands. The VPA focused the surveys on 13 different categories, namely communication, electricity, transport, health, recreation, education, employment, poverty, housing, food security, drinking water quality, consumer goods, and living environment. The questions on each category were summarised by the VPA by using an index to describe the status quo on each island for each category. These indices are used in this research as measures of socio-economic development levels for each island. Similar to the Tsunami Impact Assessment, the measures are estimated for islands where missing data uses the mean of their Atoll District. All VPA variables were recoded from 0 (not vulnerable) to 1 (very vulnerable). The VPA variables were grouped into four different categories: (1) *Primary needs*, (2) *Development,* (3) *Services*, and (4) *Living environment* (see Table 4.2). The respective variables were summed in each category. By grouping the variables in different groups the analysis of the regression models is significantly simplified. The five categories each represent distinct island characteristics.

4.5 Methodology

This paper uses island characteristics to predict the size of migration flows between all islands in the Maldives. Models consisting of migration flows within a nation or region are often based on gravity theory (Grigg, 1977; Zipf, 1946). Gravity models are based on population size and the distance between both the origin and destination of migration. Distance is expected to have a negative influence on migration, whereas population size at both origin and destination is expected to be positively related to the size of migration flows. Where multivariate models are often used to analyse individual or household level migration in combination with environmental data while controlled for socio-economic variables, aggregate migration flows are also often analysed using gravity models (Fussell et al., 2014). A wide range of studies have been performed in recent years modelling migration flows driven by both socio-economic, as well as environmental data using gravity models (e.g. Curtis and Schneider, 2011; Henry et al., 2003; Kim and Cohen, 2010; Marchiori et al., 2012). This study uses gravity theory to analyse migration flows between islands in the Maldives. The flow of migrants is defined as the count of migrants between all possible islands of origin and destination. As the matrix of migrant flows is sparse and consists of a large spread in size, with many low or zero values and few very high values, it is appropriate to use Poisson regression models as generalised linear models (Bohara and Krieg, 1996; Boyle and Flowerdew, 1993; Leyk et al., 2012; Lovett and Flowerdew, 1989). A Poisson model uses a logarithmic link to linearly produce estimates of the dependent variable. These predicted values in a Poisson regression model are estimated by the maximum-likelihood

estimate of the mean of a Poisson-distribution variable. This mean is logarithmically linked to the linear predictor by using a set of explanatory variables (Venables and Ripley, 2002).

4.5.1 Regression models

Three models of increasing complexity are considered as follows. They all follow equation (1), where γ_{ij} represents the estimated migration flow between the island of origin *i* and destination *j* and β_0 represent the intercept term. In the first model, $X_{gravity}$ and its associated regression coefficients $\beta_{gravity}$ consists of distance and population variables, which are, in accordance with the gravity model, represented using a logarithmic link. In addition the gravity model consists of contiguity and category variables. The second model adds socio-economic variables. The regression coefficients and variables included in the socio-economic model are based on the 2006 census and represented by $\beta_{soc\text{-}eco}$ and $X_{soc\text{-}eco}$. The third model adds five socio-economic and physical vulnerability indices, which are represented in equation (4.1) using the last term, β_{vuln} and X_{vuln}.

$$\gamma_{ij} = exp\left[\beta_0 + \beta_{gravity}X_{gravity} + \beta_{soc-eco}X_{soc-eco} + \beta_{vuln}X_{vuln} + \varepsilon_i + \varepsilon_j\right] \qquad [4.1]$$

The Poisson distribution assumes that the variance is equal to the mean (var/mean = 1) and if this assumption is violated this could be due to overdispersion of data (Fox, 2008). Furthermore, differences between characteristics of islands and its coastal communities that are not included in the analysis may cause variation that is not generalisable to the independent variable. To account for these differences between islands and to account for overdispersion generalised linear mixed effect models are constructed (e.g. Congdon, 2010; O Siddiqui, 1999). The linear predictor in generalised linear mixed effect models consists of both fixed effects parameters and random effects. A random effects term ε is added to the model for both islands of origin *i* and destination *j*, representing push and pull characteristics for each island that are not included in the regression model, see equation (1). The database and figures were created, and generalised linear mixed effects models fitted and tested using R statistical software version 3.1 (R Core Team, 2014) with the 'lme4' package (Bates et al., 2014).

4.5.2 Regression diagnostics

All variables included and the residuals of the models were carefully checked using a series of regression diagnostics. These include checking residual and random effects plots for outliers and influential observations, normality, and heterogeneity. The correlations of all predictor variables and the variance inflation factor (vif) of all variables were assessed to analyse potential

multicollinearity in the regression models. Variables were omitted if the vif > 2.5, where the variable with the highest vif was omitted first (e.g. Allison, 1999).

4.6 Results

The section presents the results of the analyses of migration flows between islands in the Maldives and the associated characteristics of islands of origin and destination. First the descriptive statistics of migration flows and variables will be discussed. Second, the results of the Poisson regression analyses will be presented.

4.6.1 Descriptive results

Between 2000 and 2006, 12 out of 20 Atoll Districts experienced negative population growth, mainly due to high rates of migration to Malé (see Table 4.3). Between 2000 and 2006, 17 Atoll Districts experienced negative net migration. In 2006, around 50% of the population of Malé was born on a different island. A total of 15,444 people arrived in Malé from other Atoll Districts, as compared to 9,584 inter-atoll arrivals of all other Atoll Districts combined. Even though the ratio of migrants arriving in Malé is positive, the number of people leaving the capital is also significant; 42% of migrants arriving in other Atoll Districts have the capital city as their origin. This reinforces the image of Greater Malé as a hub for migration and population growth in the Maldives. Further it shows that other population centres such as Addu City, despite their relative large size, also experience net out-migration. Migration within Atoll Districts account for 27% of migration flows between islands.

Migration flows to and from Malé also dominate migration patterns on island level. Figure 4.3 shows that from the 50 largest migration streams between islands only three originate from Malé, 16 are migration streams between other islands and 31 are migration streams to Malé. Sixty-five per cent of all islands experience net out-migration. The large migration streams between islands in North Maalhosmadulu, North Miladhunmadulu, and Kolhumadulu are related to population displacement and population consolidation programmes after the 2004 Tsunami.

Table 4.3 Population, arrivals, departures and migration rates of Atoll Districts between 2001 and 2006. The table does not describe local movements within atolls, which constitutes 27% of internal migration flows within the Maldives.

Atoll District	Population (2006)	Arrivals	Departures	Net migration	Immigration rate (%)	Emigration rate (%)
Malé Atoll	104,532	15,444	6,608	8,836	14.8	6.3
North Thiladhunmathi	13,495	500	1205	-705	3.7	8.9
South Thiladhunmathi	16,237	721	1274	-553	4.4	7.8
North Miladhunmadulu	11,940	491	814	-323	4.1	6.8
South Miladhunmadulu	10,015	450	940	-490	4.5	9.4
North Maalhosmadulu	14,756	573	1109	-536	3.9	7.5
South Maalhosmadulu	9,578	527	774	-247	5.5	8.1
Faadhippolhu	9,190	458	693	-235	5.0	7.5
North Ari Atoll	5,776	598	550	48	10.4	9.5
South Ari Atoll	8,379	913	629	284	10.9	7.5
Felidhu Atoll	1,606	157	171	-14	9.8	10.6
Mulakatholhu	4,710	217	579	-362	4.6	12.3
North Nilandhe Atoll	3,765	145	326	-181	3.9	8.7
South Nilandhe Atoll	4,967	382	514	-132	7.7	10.3
Kolhumadulu	8,493	513	1031	-518	6.0	12.1
Hadhdhunmathi	11,990	630	752	-122	5.3	6.3
North Huvadhu Atoll	8,262	442	720	-278	5.3	8.7
South Huvadhu Atoll	11,013	555	1240	-685	5.0	11.3
Gnaviyani	7,636	313	630	-317	4.1	8.3
Addu Atoll	18,026	999	1842	-843	5.5	10.2

Source: Population and housing survey, 2006. National Bureau of Statistics, Department of National Planning, Maldives

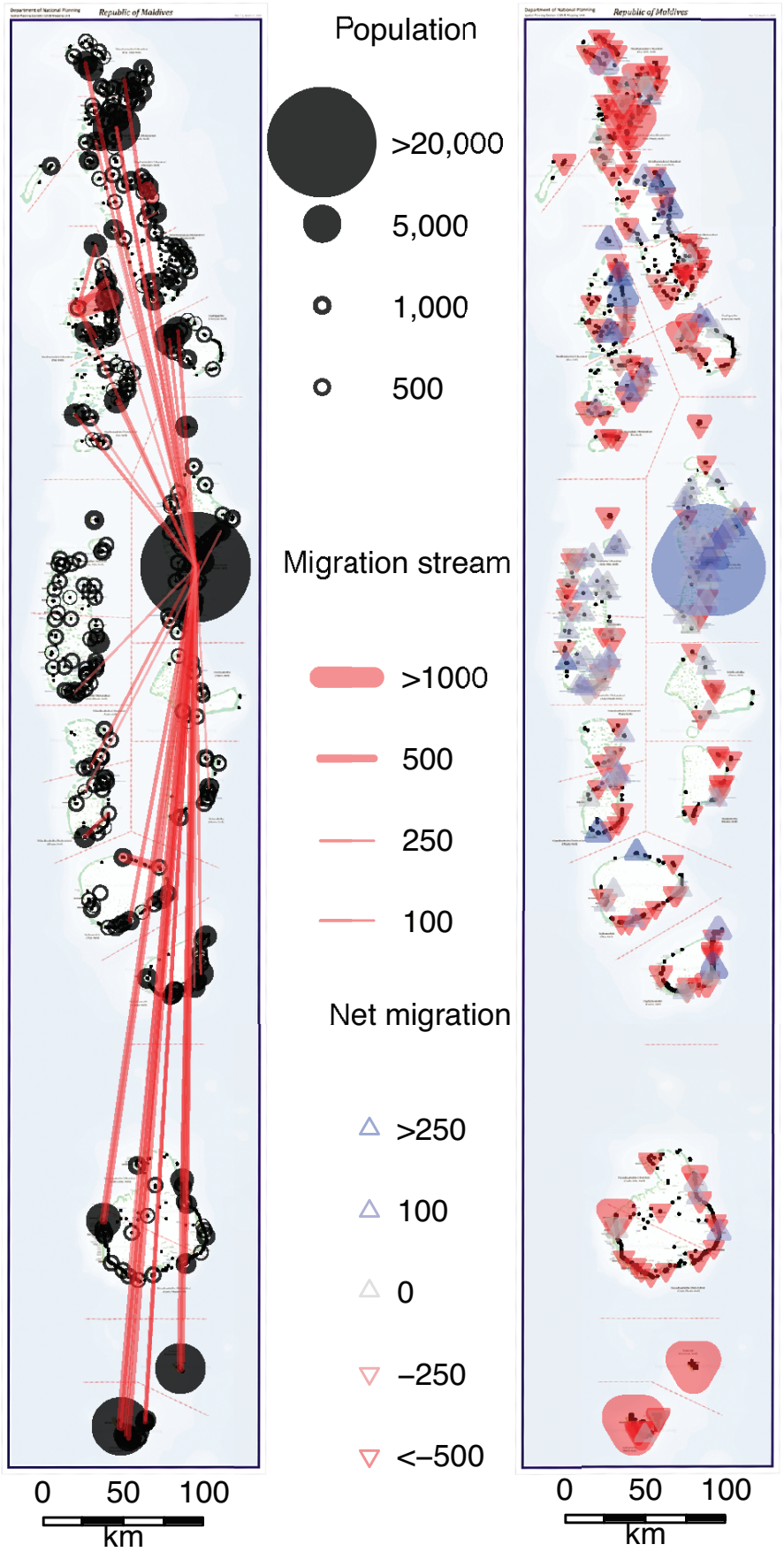

Figure 4.3 (Left panel) 50 largest migration streams in the Maldives. (Right panel) Net migration on all islands.

Table 4.4 Descriptive statistics of island-level characteristics in 2006 (N=376).

	Variables	Mean	σ	min	max
Model 1: Gravity model[a]	Migration flows	0.35	8.08	0	1485
	Distance (km)	246.8	178.63	0.004	868.6
	Population	866	4,812	1	92,555
	Contiguity	0.068	0.25	0	1
	Category	1.19	0.52	1	3
Model 2: Socio-economic model[a]	Age	28.11	6.22	16.3	72
	Sex	0.66	0.25	0	1
	Marital status	0.43	0.14	0	1
	Literacy	0.89	0.088	0.38	1
	Education	6.68	1.57	4	13
	Employment	0.58	0.31	0	1
	Hours worked	7.27	3.03	0	22
Model 3: Vulnerability model[c]	Physical vulnerability	0.85	0.50	0	2.75
	Primary needs	1.11	0.44	0	2.79
	Development	0.91	0.31	0.13	1.97
	Services	1.07	0.38	0.18	3.23
	Living environment	1.24	0.40	0.14	2.43

Source: a) Population and housing survey, 2006, by the National Bureau of Statistics, Department of National Planning, b) Maldives and Tsunami Impact Report, 2005, by the Department of Planning and National Development of the Republic of Maldives and the UNDP Maldives and c) Vulnerability and Poverty Assessment, 2004, by the Department of Planning and National Development of the Republic of Maldives and the UNDP Maldives

The summary statistics of the demographic variables and the socio-economic and physical indices show that there are large differences between island communities (see Table 4.4). The mean population of the islands is low, at 866, with a standard deviation of 4,812, showing the large dispersion of Maldivian population. The maximum population of 92,555 is the main island of Malé. The municipality of Malé has a population of 103,693, but includes separate islands such as Villingili and Hulhumalé, which are considered individually. The second city of the Maldives is Addu City, with a population of 9,297 in the main administrative district Hithadhoo. There are only two other islands with a population of over 5,000 in 2006, Fuvahmulah and Kulhudhuffushi. The mean of *Age* of all islands is lower compared to the actual mean of the population (25.6 years), indicating that there is a skewed distribution of average ages on islands. There is a high mean of 0.67 of *Sex* on the islands, indicating that on many islands there is a skewed proportion of males and females. The minimum and maximum values of socio-economic variables are strongly influenced by islands with a low population. For example, resort islands often only employ male Maldivian employees. In summary, Table 4.4 shows there is a large differentiation between population size and structure, functions, levels of development, and socio-economic and

physical vulnerabilities of island communities in the Maldives. The effects of these variables on migration will be discussed in the regression models below.

4.6.2 Poisson regression

Migration streams are expected to be higher to and from islands with higher population and distance between origin *i* and destination *j* is negatively related to the size of migration streams (see Table 4.5). These results correspond with gravity theory. *Contiguity* is also significant and has a positive effect, showing that local moves within the administrative district are preferred. The *Category* variables indicate that people are more likely to move between islands with administrative and residential functions.

Following from the regression diagnostics, the *Employment* and *Sex* variables were dropped from the analysis due to high multi-collinearity. This shows that many males migrate for purposes of employment to other islands, resulting in skewed proportions of gender and employment on different islands and that there is a strong relation between the share of males on an island and other measures included in the regression. The regression coefficients may be interpreted as follows. Migration is higher between islands with a relatively old population. This could be due to a low share of young children on for example a resort or an industrial island, compared to smaller residential islands where there are more children. People move more often from islands where the average amount of hours worked is lower to islands where the average amount of hours worked is higher. Additionally migration tends to be higher to islands with a relatively high proportion of high-educated people and high literacy rates, whereas islands of origin tend to have lower rates of literacy and education. This corresponds well with earlier findings that education has a positive effect on migration (Fields, 1982; Hunter et al., 2014; Lindstrom and Ramírez, 2010).

Using the gravity model and the socio-economic model as control measures, the socio-economic and physical vulnerability indices were introduced. The *Environment, Primary needs*, *Development, Services*, and *Living environment* variables all show that there are larger migration streams from more vulnerable to less vulnerable islands.

Table 4.5 Results of the Poisson regression models predicting the size of migration flows of 376 islands and 375 possible destinations (N=141,000).

	Variables	*β i*	Std. error *i*	Sign. *i*	*β j*	Std. error *j*	Sign. *j*
Model 1: Gravity model[a]	Intercept	-13.139	1.43	***			
	Distance	-0.200	0.0073	***			
	Population	0.504	0.050	***	0.935	0.049	***
	Contiguity 1	2.636	0.024	***			
	Category 1	-1.116	0.24	***	-0.477	0.19	***
	Category 2	-1.821	0.34	***	-1.081	0.25	***
Model 2: Socio-economic model[a]	Age	0.0256	0.0095	***	0.0387	0.0089	***
	Marital status	0.928	0.38	***	0.436	0.12	***
	Literacy	-3.412	1.06	***	2.329	0.90	***
	Education	-0.0344	0.012	***	0.345	0.041	***
	Hours worked	-0.0493	0.012	***	0.0568	0.021	***
Model 3: Vulnerability model[c]	Physical vulnerability	0.432	0.041	***	-0.112	0.0094	***
	Primary needs	0.131	0.0036	**	-0.305	0.095	***
	Development	0.0380	0.012	**	-0.369	0.039	***
	Services	0.339	0.087	***	-0.0712	0.034	*
	Living environment	0.41	0.092	***	-0.11	0.012	***

Source: a) Population and housing survey, 2006, by the National Bureau of Statistics, Department of National Planning, b) Maldives and Tsunami Impact Report, 2005, by the Department of Planning and National Development of the Republic of Maldives and the UNDP Maldives and c) Vulnerability and Poverty Assessment, 2004, by the Department of Planning and National Development of the Republic of Maldives and the UNDP Maldives

$p \leq 0.05$; *
$p \leq 0.01$; **
$p \leq 0.001$ ***

4.7 Discussion

This section explores the characteristics and possible future development of migration flows between islands in the Maldives and the wider implications and limitations of this study are discussed.

4.7.1 Characteristics of migration

There is a large differentiation in characteristics of island communities in the Maldives. Its population is highly dispersed and there are large differences in levels of development, vulnerability, functions, and population size and structure of island communities. Greater Malé is the nation's only real urban area and the economic centre of the Maldives, with about one third of the national population. Migration flows to and from Greater Malé dominate migration patterns in the Maldives. Thirty-one of the fifty largest migration flows have Malé as its

destination, and sixteen as its origin. This is in stark contrast to many of the low population islands: most of these islands are experiencing high rates of out-migration, resulting in declining populations. In addition to voluntary migration, three out of fifty largest migration streams can be attributed to the 2004 Tsunami and the population consolidation programme of the Maldivian government. Local movements within Atoll Districts constitute 27% of migration flows in the Maldives. These are smaller flows between islands with a lower population. This shows that local developments and characteristics of island communities also play an important role in describing migration flows in the Maldives.

The Poisson generalised mixed effect linear regression models presented in this study provide evidence on the context of these migration flows. A gravity model including population size, distance between islands, and economic functions of island communities is used as a basis for the regressions and provides a good first description of migration in the Maldives. A second model based on the 2006 census data shows that summary statistics on an island level of age, marital status, education, literacy, and employment help describe migration flows. It shows that the population on islands of destination are generally better educated and work longer hours compared to islands of origin. In addition socio-economic and physical vulnerability indices add explanatory detail to their relationships. In general more vulnerable island communities experience higher rates of out-migration and islands of destination are better developed in terms of *Primary needs*, *Development, Services*, and *Living environment* indicators. The *Environment* indicator further adds to this analysis. Migration flows are larger from islands with a higher vulnerability to physical threats to islands where vulnerability is lower. While the database used does not include significant storms or energetic swell events, like the 1987 swell which caused widespread flooding including Malé (Pernetta, 1992), it can be hypothesised that there would be a similar relationship to migration streams as the *Tsunami impact, Beach erosion,* and *Reef damages* variables.

4.7.2 Population policies and future demographic developments

The government of the Maldives is already faced with significant development choices regarding investments on low population islands due to the relative high investment to provide adequate services such as education, healthcare, and sanitation for small populations. This resulted in policies related to population consolidation, policy programmes aimed to relocate island communities from poorer islands with a lower population to more developed islands, mainly using arguments of economy of scale. In 2006, 3356 people indicated they migrated within the framework of population consolidation programmes. As investments are primarily focused around existing population centres, the population consolidation programmes could further

reinforce the differentiation of socio-economic vulnerabilities and population size between islands in the Maldives.

Further, the potential impacts of sea-level rise are likely to result in greater costs for adaptation for a small island nation with a comparatively low GDP such as the Maldives (Anthoff et al., 2010; Nicholls and Tol, 2006). Given these high costs the government of the Maldives is likely to have to prioritise such investment. It can be hypothesised that such investments are likely to follow similar arguments of economy of scale as those related to providing socio-economic services. Their National Adaptation Plan of Actions (NAPA) already focuses on a set of 'Safer Islands' (Ministry of Environment, Energy and Water, 2007). The NAPA also indicates that to 'consolidate population and development' should be one of the main focus areas for reducing vulnerability to climate change. This is further emphasized in the 7th National Development Plan of the Maldives, where the former President Abdul Gayoom stated that the 2004 tsunami reinforced the established policy of encouraging voluntary population movement to less vulnerable islands (Ministry of Planning and National Development, 2007). However, Kothari (2014) argues that such environmental discourses are being emphasised to justify and support unpopular existing population consolidation policies.

This shows that the existing process of people leaving more vulnerable and lower population islands is likely to continue and even be reinforced by policy decisions and investments in the future. Investments are focused around Malé and Hulhumalé in particular. As buildings in Malé will increase in height (and capacity) and the artificial island of Hulhumalé is under development, Greater Malé is likely to continue to have a strong pull factor for potential migrants for decades to come. Preliminary results of the 2014 census already indicate that a higher share of the nation's population is residing in Greater Malé as compared to 2006 (National Bureau of Statistics, 2015). These processes, combined with policies to reduce population dispersion and develop a smaller number of populated islands, will inevitably encourage a further decrease of population in the many less populated islands due to high rates of out-migration and a reduction in the number of inhabited islands in the Maldives.

4.7.3 Island abandonment, migration, and climate change

Discussions about island abandonment and out-migration in small island settings are often linked to climate change and sea-level rise. This study shows that potential future island abandonment of islands in the Maldives cannot be linked to sea-level rise and climate change alone, as current trends already show high rates of out-migration from more vulnerable and lower populated islands and this is likely to continue even without environmental change. The case of the Maldives

shows that contemporary processes and trends are fundamental in understanding migration flows and potential future island abandonment.

There is a risk in the discourse about migration and the environment that changes in migration flows and future island abandonment are attributed to climate change, especially in vulnerable settings such as small island states. Further, estimating future changes in migration flows due to climate change often neglect changes in socio-economic circumstances. However, socio-economic developments, like the development of Hulhumalé in the Maldives, inevitably alter demographic trends. These developments need to be considered, together with environmental change, when assessing or estimating future migration flows.

The impacts of climate change and sea-level rise on migration will be defined both by its physical impacts as well as the response and development of coastal societies. The responses of coastal societies and changes in migration flows will differ depending on their socio-economic setting. Understanding the potential component and effect of climate change on future changes in migration flows therefore requires integrative methods to studying migration flows. In the Maldives, climate change could exacerbate existing processes, but changes in policies or increase of investments in areas outside Greater Malé could potentially counter such developments. Future studies linking migration and the environment should carefully consider its socio-economic setting as well as its potential future socio-economic developments, also where the potential impacts of climate change are high. Such an approach is often lacking in migration research.

4.7.4 Limitations

This study has a number of limitations that can be categorised in two parts. Firstly, migration, environmental change, and processes influencing levels of vulnerability and development of islands are all dynamic processes and are best approached by using time-dependent longitudinal designs. The measures for both environmental and socio-economic vulnerability are not based on census data and are limited in sample size since full coverage would be practically impossible and prohibitively expensive (Hameed and Coeur-Bizot, 2004). Furthermore, foreigners who temporarily reside in the Maldives for employment purposes are not included in the analysis. According to a 2010 report on Human Trafficking by the United States Department of State, it was estimated that 110,000 foreigners, primarily of Bangladeshi descent, were working in the Maldives mainly in the construction and service sectors (U.S. Department of State, 2010). This number is likely to be increasing. Lastly, Maldivians who have temporarily left the Maldives for education, health, or employment purposes are not included in the census.

Secondly, this study used generalised linear mixed effects models to describe migration on a nation-wide scale. The very high statistical significance presented in this study show that the definition of the statistical model can possibly be further improved. For example, the reliability of the statistical significance and results of the regression analyses could be improved by evaluating the adaptive Gauss-Hermite quadrature approximation at more points for greater accuracy in the evaluation of the log-likelihood compared to the standard Laplace approximation (Pinheiro and Chao, 2006). More detailed analyses of the interdependencies between spatial interactions of migration flows using a range of datasets could provide further insights (e.g. Chun and Griffith, 2011).

4.8 Conclusion

Despite the high profile of low-lying islands in the debate on impacts of climate change and sea-level rise and its potential effects on coastal societies, there have only been limited efforts to analyse the magnitude and drivers of contemporary migration on low-lying islands. This paper fills this gap and provides a unique insight into contemporary demographic processes in a small island nation.

There are large migration flows between islands in the Maldives: 21% of the population was identified as migrants between 2001 and 2006. These present migration flows are occurring due to non-climate processes. Urbanisation is important in the Maldives, like in many other developing countries. The capital island Malé dominates national migration flows and is likely to continue to have a strong pull factor for potential migrants for decades to come. This is in strong contrast to many islands with low populations, which are experiencing high rates of out-migration and declining population. There is a large differentiation in characteristics of island communities in the Maldives. Different levels of development, vulnerability, and population size and structure help describe the size of migration flows. Higher socio-economic, and physical vulnerabilities of island communities indicate higher rates of out-migration. These processes are reinforced by selective land reclamation projects across the nation and at Hulhumalé in particular, intense urbanisation on Malé, and the national population consolidation and 'Safer Islands' policies. This suggests that the existing trend of people leaving low population and vulnerable islands is likely to continue even without environmental change. However, climate change can potentially exacerbate existing trends in the Maldives, leading to enhanced out-migration from more vulnerable islands to better protected and wealthier areas within the Maldives, and possibly internationally.

This study shows that it is fundamental to recognise and understand existing processes in analysing future migration trends. The case of the Maldives demonstrates that potential future island abandonment of islands and changes in migration flows cannot be linked to sea-level rise and climate change alone. The result is likely to be generic across small island states. Future studies should carefully consider its socio-economic setting and its potential future socio-economic developments, also where the potential impacts of climate change are high.

Chapter 5 Contemporary migration intentions in the Maldives: The role of environmental and other factors

5.1 Abstract

Migration is often mentioned as a major potential impact of climate change for small island states, especially low-lying atolls. Understanding future migration flows, including the potential role of environmental change, requires an interdisciplinary approach, focusing both on environmental *and* socio-economic factors. This paper presents a detailed analysis of contemporary migration decision-making processes in a small island nation – the Maldives – based on a survey conducted in 2015. The results challenge the widely held view that climate change is influencing contemporary migration behaviour in the Maldives. The survey shows how attitudes influence intention to migrate both internally and internationally. Existing analysis of the national census shows a strong urbanisation trend, with significant net migration to the capital island Malé and its environs, dominating national migration flows. People consider perceived employment and educational opportunities, quality of health services, and expectations about general quality of life, happiness, and social environment. In addition, many Maldivians have a high intention to migrate internationally. Hence, changes in barriers to international migration by, for example, establishment of international migrant networks, or policies enabling migration from the Maldives, are likely to increase international migration in the near future. Maldivians widely express knowledge and concern about climate change and sea-level rise recognising the high vulnerability of the island nation. However, such considerations are not presently important in their decisions about migration.

Keywords: Migration; Small Islands; Climate Change; Theory of Planned Behaviour

5.2 Introduction

The threats of climate change and sea-level rise to small islands are well established (Nurse et al., 2014). Related drivers of risk include sea-level rise, changes in both frequency and intensity of storms, increasing air and sea surface temperatures, and changing rainfall patterns. These are in turn likely to impact the ecosystems on which people living on small islands depend, including coastal erosion and inundation, salinisation of fresh water lenses, coral bleaching, changing abundance and distribution of fish species, and agriculture. Further impacts on various key economic sectors such as tourism and ports/shipping could be significant. Global analyses suggest that island regions will experience the largest relative increase in flood risk due to sea-level rise in the coming century (Nicholls et al., 1999; Nicholls, 2004), and low-lying atoll regions appear to be consistently vulnerable across a wide range of scenarios (Nicholls and Tol, 2006). These studies all reinforced the high vulnerability of small island states and especially low-lying atoll islands. This vulnerability is further enhanced as many of the small island states have limited resources and are ill-equipped to deal with existing environmental problems and issues such as large population growth, overdevelopment, and pollution (Leatherman and Beller-Sims, 1997) and the characteristics of small island states present many difficulties for sustainable development (Maul, 1996).

The first papers and Intergovernmental Panel on Climate Change (IPCC) assessment on climate change and its impacts on small islands in the early 1990s already suggested that sea-level rise could lead to total inundation of small low-lying islands (especially coral atolls) and mentioned migration and ecological refugees as the major potential impact of climate change for small island states (Lewis, 1990b; Pernetta, 1989, 1992; Tegart et al., 1990). This view has been reiterated in all subsequent IPCC assessments (Bijlsma et al., 1996; McCarthy et al., 2001; Mimura et al., 2007; Nurse et al., 2014; Watson et al., 1997; Zinyowera et al., 1995). More recently, the potential high costs of adaptation to sea-level rise and climate change for islands was suggested as a driver of migration (Biermann and Boas, 2010; Gemenne, 2011; Nicholls et al., 2011).

Despite the abundance of theoretical links between climate change and migration, there is a lack of studies empirically relating climate change and sea-level rise to migration in a small island setting (Lilleør and Van den Broeck, 2011; Mortreux and Barnett, 2009; Speelman et al., submitted-a (see Chapter 3)) and surprisingly little research on present migration intentions and flows within and external to island nations. Understanding the vulnerability of small islands and linking sea-level rise and climate change with migration in a small island setting requires a broader scope than to look at impacts of sea-level rise and climate change alone. Migration is occurring today driven by a multitude of factors (Black et al., 2011a) and sea-level rise and climate change

are potential *additional* drivers of migration (e.g. Birk and Rasmussen, 2014; Connell, 1987; Shen and Binns, 2012). To understand future migration trends, empirical research should therefore be embedded in both existing socio-economic and demographic processes and its potential environmental components. This requires advances in empirical migration research. Such advances depend on increased collection of quantitative data; adoption of sophisticated statistical modelling approaches; and greater collaboration between environmental and migration researchers (Fussel et al., 2014).

Contemporary migration processes in small island settings are not well understood and this study addresses this gap using the Maldives as a representative case study. It gives a unique insight in migration processes in a small island setting and presents methods to study contemporary migration intentions in relation to environmental pressures. This research uses the Theory of Planned Behaviour with the inclusion of an *Environmental Attitude* to migration as a framework to analyse intentions to permanent internal and international migration in the Maldives. This study is based on fieldwork conducted in the Maldives between 5th February 2015 and 24th March 2015, including respondents from 18 different islands, which generated 192 quantitative surveys.

The paper is structured as follows. First, the Maldives are introduced. Second, existing studies on migration in a small island setting are analysed based on a systematic literature review. Section 5.5 provides a framework for the analysis using the Theory of Planned Behaviour. Section 5.6 describes the interview procedures, the theoretical background of the survey and the statistical methods applied in analysing its results. Section 5.7 presents the results, section 5.8 discusses them, and lastly conclusions are drawn.

5.3 The Maldives

The Republic of Maldives, at 298 km^2, is the sixth-smallest sovereign state in terms of land area. The land is divided into 1,192 coral islands, of which 96% are less than 1 km^2 in area. Shallow lagoons enclosed by coral reefs surround the islands with an average height of only 1.6 meters and a highest point of 2.4 meters. Woodworth (2005) and Church et al. (2006) confirmed that sea-level rise observations in the Maldives are consistent with global trends of sea-level rise.

The Maldives is a Sunni Muslim society and its constitution is based on sariatu, the Maldivian interpretation of the traditional sharia. In 2006, 193 islands were inhabited and 91 islands had been developed as tourist resorts. The preliminary results of the 2014 census estimate that the population of the Maldives in 2014 is 399,939 (National Bureau of Statistics, 2015), including guest workers. Guest workers are an increasingly important factor in demographic processes in the Maldives. The 2014 Census is the first to try and assess their numbers, with an estimate of

58,683 people. However, an earlier estimate for 2010 was 110,000 people (U.S. Department of State, 2010) and it may take time to develop robust and agreed estimates. Certainly the numbers seem appear to be growing.

The population of the Maldives is dispersed. The capital island of Malé is the centre of economic development, services, and political power and it has grown to a population of about 127,079 on an island of 1.98 km^2, resulting in a population density of 64,148 people per km^2 (National Bureau of Statistics, 2015). Building heights also increased (currently limited to 12 stories), but taller buildings (to at least 20 stories) are planned. The neighbouring islands Hulhumalé and Villingili have a population of 15,769 and 7,790, respectively. Only 11 other islands have a population of over 2,500.

Malé is protected from high tides and extreme waves by a series of breakwaters first built after significant wave-induced flooding in 1987 (Pernetta, 1992). To release population pressure on the capital island and spur economic growth, the artificial island of Hulhumalé is being constructed nearby in phases. The island will be able to house 60,000 people in 2020 at completion of phase I and further expanded to *at least* 100,000 people at completion of phase II, which was launched late 2014 (Hulhumalé Housing Development Corporation, 2015). However, the island could house a population at higher densities than planned, resulting in a higher potential future population. The island of Hulhumalé has been constructed at a height of roughly 2 meters above mean sea-level, roughly 0.5 m higher than the average height of natural islands. This provides some freeboard for storms and other extreme marine events (e.g., tsunamis), as well as sea-level rise.

There are high rates of internal migration in the Maldives. Speelman and Nicholls (submitted) (see Chapter 4) analysed these flows based on environmental and census datasets. On a national scale migration flows are dominated by the capital city Malé. A classic migration model including population size, distance, and factors such as age and education provides a good first order description of this migration. Additionally, people in the Maldives moved from more socio-economically and environmentally vulnerable islands to less vulnerable islands. Population on many of the lower populated and more vulnerable islands is decreasing. This process is further enhanced by the “Population Consolidation Programme”, which the government of the Maldives initiated to (1) develop stronger regional centres, (2) reduce the dispersion of population over the archipelago, and (3) reduce the associated costs of development (Ministry of Planning and National Development, 2004). Its principles can be extended to potential investments and migration policies in protection from coastal hazards, which includes adaptation to climate change. On the basis of this premise, the government of the Maldives developed the “Safer Islands” strategy. The “Safer Islands” are designated islands that are relative large and better

protected from natural disasters, where communities from smaller, more vulnerable islands can be resettled (Ministry of Environment, Energy, and Water, 2007). However, Kothari (2014) argues that the "Population Consolidation Programme" is unpopular and that this policy is essentially reframed in terms of environment and climate change to the "Safer Islands" strategy in order to provide funding and political leverage in its implementation.

5.4 Migration and small islands

Scholars have discussed migration processes in small island settings in the past. Speelman et al. (submitted-a) (see Chapter 3) conducted a systematic literature review to obtain an overview of determinants important in migration processes in small island settings (see Table 3.2). The determinants so-identified were used as a basis for developing questions for the field survey.

Perceived employment opportunities at the place of destination, or lack thereof at place of origin were most widely studied and all these studies identify this as an important factor in migration decision-making. Migrant networks, age, remittances, education, and identity are the only other factors mentioned by five or more studies. The remaining determinants were identified in fewer studies and represent a small geographic spread.

Differences in political, cultural, socio-economic, and biophysical conditions all influence migration and result in different patterns between the small island nations. For example, remittances play a large role in migration dynamics in the South Pacific and Caribbean (Brown and Connell, 2006; Brown et al., 2014; Brown and Leeves, 2010; Connell and Conway, 2000; Leeves, 2009). However, in the Maldives, remittances are not an important factor in the present economy, measuring only 0.20% of GDP in 2010 (Ratha et al., 2011). The size of these remittance flows can be related to migrant networks. As large numbers of islanders from South Pacific islands have moved to New Zealand and Australia migrant networks are well developed. These networks ensure that potential migrants already have a cultural bond with the place of destination and often already have kin living at the place of destination. Such networks can thus help overcome initial migration difficulties (Birk and Rasmussen, 2014; Connell, 2008; Fog Olwig, 2012; Leeves, 2009; Locke, 2009; Shen and Gemenne, 2011; Wilson, 2013).

5.5 The Theory of Planned Behaviour

This study uses the well-established Theory of Planned Behaviour (Ajzen, 1991) as a framework for the analysis. The theory is based on the assumption that human beings in general behave in a rational manner and that they use available information to perform (or not perform) a certain

action. The theory postulates that there are three main factors influencing intention. The first factor is the attitude towards the behaviour. Attitude describes the individual's positive or negative evaluation toward the behaviour. In this study, attitude was subdivided into three components: (1) *Instrumental Attitude*, (2) *Affective Attitude,* and (3) *Environmental Attitude.* The *Instrumental Attitude* describes the individual's evaluation regarding perceived costs and benefits related to migration. *Affective Attitude* includes personal feelings and opinions toward the behaviour.

Further, this study explicitly includes opinions and perception about the environment in the decision model by adding a third component, *Environmental Attitude.* By *explicitly* including environmental considerations to the development of intentions to migrate, individuals perception of environmental factors such as environmental degradation or the perceived threat of climate change and sea-level rise to their place of residence and its effects on the development of intentions to migrate can be assessed. The opinions and views of individuals about environmental issues can in this way be de-coupled from socio-economic considerations and the effects of each different component can be assessed individually.

The second factor describes *Subjective Norms*, or the person's perception of social pressure to perform the behaviour. The third factor is the *Perceived Behavioural Control*. This factor describes the person's perceived self-efficacy or ability to perform the behaviour. If these three factors are positive, a person is more likely to have a positive intention to perform the behaviour. The importance of each factor depends on the studied behaviour. Positive intention generally translates into actual behaviour. However, obstacles such as habit formation and other environmental constraints can cause a person with a positive intention to refrain from performing the planned behaviour. In contrast, skills, knowledge, and other facilitators can have a positive effect.

Implicit to the Theory of Planned Behaviour are factors influencing attitudes, norms, and perceived behavioural control. These *Background Factors* affect the motivational beliefs as postulated in the Theory of Planned Behaviour, which in turn predicts intention (see Figure 5.1). *Background Factors* include demographic variables such as level of education, age, marital status, personality traits, and other individual differences that can influence behaviour indirectly (Fishbein, 2000).

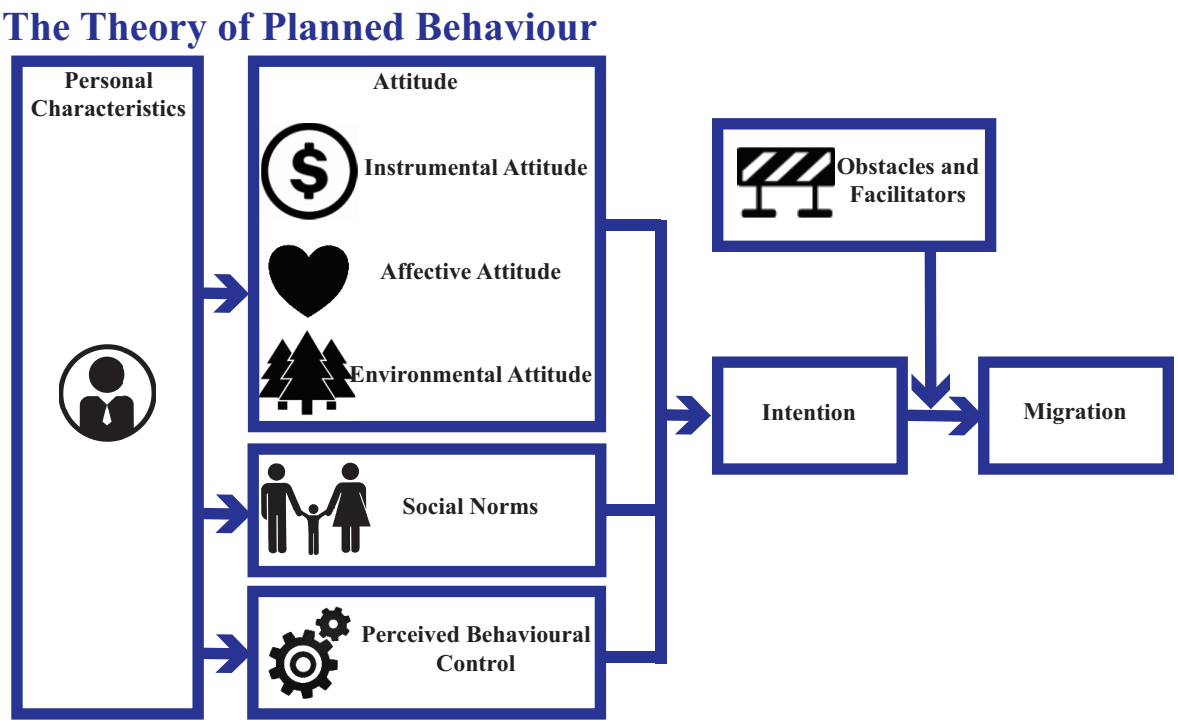

Figure 5.1 The Theory of Planned Behaviour as applied to the Maldives.

5.6 Methods

This study considers how personal characteristics and attitudes toward migration behaviour influence the intention to migrate in the Maldives. Special attention is paid on how Maldivians experience the current and future role of the environment. The study takes a quantitative cross-sectional approach and focuses both on internal and international migration. For the purpose of this research only Maldivian citizens are considered and guest workers are not included.

5.6.1 Data collection

The analyses presented in this paper are based on fieldwork conducted in the Maldives from 5th February 2015 to 24th March 2015. A total of 192 surveys were generated. The survey includes respondents living on 18 different islands. The respondents are between 16 and 64 years old, with a mean age of 28. Fifty-four per cent of the respondents are female and all respondents are Maldivian. Further descriptive statistics can be found in section 5.7.

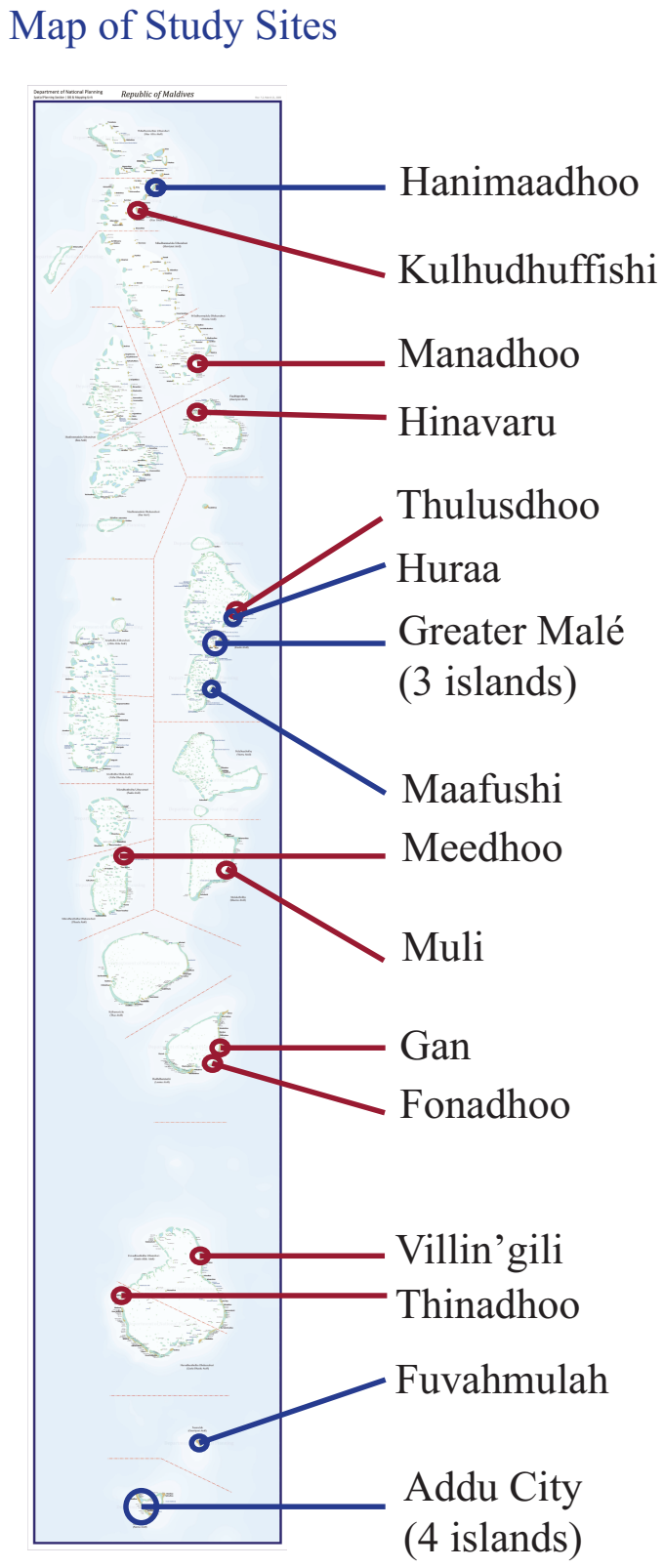

Figure 5.2 Map of the Maldives and selected study sites. The blue circles indicate islands where interviews were completed. Red circles indicate additional islands where people have completed surveys online.

Islands were selected to include islands with wide range in population size, island function, and location across the Maldives (see Figure 5.2). Hulhumalé, Malé, and Villingili ("Greater Malé") were selected as the area is the economic, political, and services centre of the Maldives and the main hub of national migration flows. In the vicinity of Malé the island of Maafushi and Huraa were visited. Maafushi is the first island to introduce guest house tourism in the Maldives and houses the largest prison in the Maldives. In the most southern atolls interviews were conducted on the islands Gan, Feydhoo, Maradhoo, and Hithadhoo (Addu City, the second largest city), as well as Fuvahmulah. In the north interviews were conducted on Hanimaadhoo. In addition, respondents from ten additional islands completed the survey online (Figure 5.2).

In terms of sampling in each island, each day a location on the island being studied was randomly selected using a random point generator. Respondents were approached in this area. The respondents were given a short introduction about the purpose of the research and it is stressed that participation is voluntary. It was then explicitly asked whether the person would like to partake and given amply time to respond. All participants were assured confidentiality. The respondent was informed that for the surveyor there are no wrong answers and that the surveyor is only interested in their views and beliefs and that their answers will not directly influence themselves. The respondent was told that the questionnaire will take approximately 30 minutes. The respondents were asked if they have any questions and are reassured that they can always decide not to answer questions or ask the surveyor a question. The respondents were thanked and given a small token gift. The introduction is included in the survey in Appendix B.

If people were not able or willing to complete the survey at time of approaching, the surveyor asked for their e-mail address so the subject could complete the survey online at a later time. The surveys were available both in English and Dhivehi (in Thaana script). In addition, people were approached indirectly by asking respondents to share a short introduction and link to the survey with their family and friends. Lastly, people were approached online through a variety of Maldivian Facebook groups. SurveyMonkey was used to gather the online responses and as a tool for data entry. The different methods for data collection were registered using different links to the survey. As there is a risk of self-selection, especially for online surveys conducted through social media, the differences between obtained answers were checked. There was no significant difference in intention to migrate between the methods. Data was analysed using R statistical software version 3.1 (R Core Team, 2014).

5.6.2 Survey design

The survey includes questions both on internal and international migration and the surveys in English are included in Appendix B. Each section associated with the theoretical framework consists of a group of questions. All statements and questions, except the background factors and open questions, are measured using a five-point Likert scale (Likert, 1932). The background factors (*BF*) consists of questions related to factors such as age, highest obtained education, and income; instrumental attitude (*IA*) with questions related to income and job prospects; affective attitude (*AA*) with those related to happiness and quality of life; environmental attitude (*EA*) with attitudes toward environmental factors; social norms (*SN*) with perceived expectations of family and friends; perceived behavioural control (*PBC*) consists of questions about the perceived ability of the subject to migrate; intention (*INT*) consists of three questions measuring intention to migrate; and lastly the open questions provide space to comment on the survey (see Table 5.1). The survey was tested and adapted before departure, and again after the first week of fieldwork after a small set of trial interviews. The *IA, AA,* and *EA* categories each consists of two parts, (1) opinions about island of current residence, and (2) expectations about migration.

Variables are created for each of the *IA*, *AA*, *EA*, *SN*, *PBC*, and *INT* categories, both for international and internal migration, by summing the answers to the questions about migration expectations. Of each section dealing with attitudes or intention the respective Cronbach's alpha is reported for both internal and international migration. Cronbach's alpha is a measure of internal consistency between 0 and 1, where as a rule of thumb a reliability of 0.7 or greater is required (Nunnally, 1978).

Table 5.1 Survey questions and statements grouped by category and associated Cronbach's alpha.

Category (Number of questions)	**Questions**	**Cronbach's alpha**	
		Internal	**International**
BF (16)	(1) How old are you? (2) What is your nationality? (3) What is your place (island) of birth? (4) What is your gender? (5) Are you married? (6) Does your spouse live on this island? (7) How many children do you have? (8) What is the size of your household (how many people live in the same house as you)? (9) What is your relationship to the head of household? (10) What is the highest level of education you have completed? (11) During last week were you engaged in any income generating activity for more than 1 hour? (12) What is the economic activity in which you spent most of the time during last week? (13) Do you own land, a house, or business? (14) What was your income in the last month (MRF)? (15) In which city (island) do you live? (16) How long	N/A	N/A

		have you lived on this island?		
IA	(6)	Opinion about island of residence (1) How happy are you with your income? (2) How happy are you with your job? (3) How do you rate the health care provision on this island? (4) How do you rate the educational possibilities on this island? (5) How do you rate crime levels on this island? (6) How do you rate the living costs on this island?		
	(6)	Expectations about migration (1) I have good connections for employment if I migrate. (2) I expect my income to increase if I migrate. (3) Do you have good job prospectives if you migrate? (4) Do you expect health care facilities to be better if you migrate? (5) If I migrate I will have better educational opportunities. (6) Crime levels play a role when thinking about migration.	0.86	0.87
AA	(4)	Opinion about island of residence (1) How happy are you with your current living conditions? (2) How happy are you with your social environment? (3) How happy are you with the mentality of the people on this island? (4) How do you rate your overall level of happiness?		
	(5)	Expectations about migration (1) Do you expect to become happier if you migrate? (2) Do you think your quality of life will improve if you migrate to another island? (3) Would you expect to live in a pleasant living environment? (4) Would you expect to live in a pleasant socially amenable community? (5) Do you expect the mentality of the people to be more pleasant if you migrate?	0.87	0.93
EA	(15)	Opinion about island of residence (1) How happy are you with clean water provision and food quality on this island? (2) How do you rate the amount of nature and space on this island? (3) How do you rate the level of quietness and peace on this island? (4) How do you rate the level of pollution on this island? (5) How do you rate the level of population density on this island? (6) How do you rate the level of protection to storms on this island? (7) How do you rate the level of environmental degradation/erosion on this island? (8) How much do you think climate change will impact this island? (9) Do the effects of sea-level rise affect your daily life? (10) Do you think sea-level rise will affect your daily life in the future? (11) Do the effects of climate change affect your daily life? (12) Do you think climate change will affect your daily life in the future? (13) Environmental degradation/erosion is a problem. (14) Environmental problems in the place I live now make life hard for me. (15) Does the threat of storms or other extreme events worry you?		
(12)		Expectations about migration (1) Maybe I will leave because of environmental problems here. (2) The environment influences my considerations about migration. (3) Nature and space are a factor when thinking about migration. (4) Quietness and peace are a factor when thinking about migration. (5) Does the level of	0.9	0.92

	pollution play a role when thinking about migration? (6) Does the level of population density play a role when thinking about migration? (7) Do you think clean water provision and food quality will be better if you migrate? (8) Do the threat of storms or other extreme events play a role? (9) Do protection measures to storms and other extreme events play a role? (10) Do potential impacts of climate change play a role? Do levels of erosion play a role? (11) Do potential impacts of sea-level rise play a role?		
SN (3)	(1) My friends and family want me to stay. (2) Do considerations about the future of your family (children) play a role? (3) If I move that must be for the benefit of my family.	0.74	0.77
PBC (5)	(1) Policies enable me to migrate to another island. (2) I know that I am capable of migration. (3) I have the economic means to move. (4) If I want to I can migrate to another island in the next year. (5) I have friends and family who migrated.	0.82	0.74
INT (4)	(1) Do you intent to migrate? (2) I would like to migrate to another island/country. (3) I will migrate in the coming two years. (4) Where would you migrate if you would move away from this island? (island code or country name)	0.86	0.87
Open questions (5)	(1) Do you have any comments or additional information you would like to share? (2) Did I miss any important aspects related to migration (and if so, what)? (3) Do you have any additional comments about the relation of environment and environmental change to migration? (4) Do you expect climate change to play a role in future considerations about migration? (5) If so, what factors we talked about today do you think would be influenced?	N/A	N/A

Two separate general linear regression models are introduced, which predict the intention to migrate internally and internationally, respectively. The variables used are all defined in Table 5.1. Following the theoretical model presented in Figure 5.1 the variables in the *BG* category are first introduced, followed by the *IA*, *AA*, *EA*, *SN*, and *PBC* variables and their respective estimates β to predict intention to migrate (*INT*), see equation 5.1.

$$INT = \beta_0 + \beta_{1-14}BF + \beta_{15}IA + \beta_{16}AA + \beta_{17}EA + \beta_{18}SN + \beta_{19}PBC \qquad [5.1]$$

All variables included and the residuals of the models were carefully checked using a series of regression diagnostics. These include checking residual plots for outliers and influential observations, normality, and heterogeneity. The correlations of all predictor variables were assessed.

5.7 Results

This section is organised as follows. First descriptive statistics on the seven quantitative categories are presented. Answers to the open questions provide context, which is used in the discussion. Second, the regression models on intention to migrate internally and internationally are discussed.

5.7.1 Descriptive statistics

First background factors will be discussed. This is followed by presentation of opinions about respondents current place of residence. Lastly migration intentions and the *IA, AA*, *EA, SN*, and *PBC* categories are discussed.

5.7.1.1 Background factors

The descriptive statistics of the background factors show that the sample includes a large spread of people (see Table 5.2). Respondents are between 16 and 63 years old, have been living on their island of residence between 1 and 63 years, and have a monthly income between MVR 0 (equivalent to USD 0) and MVR 175,000 (USD 11,371). More females participated in the survey and the average level of highest attained education is slightly higher compared to the national average. The average size of household of 6.44 corresponds well with the national average. The high average household size is mainly due to large households in the capital city of Malé, where people live in apartments and houses with extended families. The largest group of people were born on Malé (98) and Addu City (34). People were born on 37 different islands. Most people included in the survey live in Malé and Addu. The survey includes respondents from 18 different islands. The most popular destination for migration (36 people) within the Maldives is the artificial island Hulhumalé next to the capital island Malé. The popularity of Hulhumalé as a potential destination for internal migration indicates the pace of development and the high expectations of Maldivians about the project. The population of Hulhumalé has increased from 2,866 to 15,769 between 2006 and 2014 (National Bureau of Statistics, 2015). Other popular destinations include Addu City (18), Malé (10), and Fuvahmulah (10). The most mentioned destinations for international migration are Australia (26), Sri Lanka (22), and Malaysia (20).

Table 5.2 Descriptive statistics of background factors (Table 5.2 a-g)

a) Distribution of numeric variables

Variables	Mean	σ	min	max
Size of household	6.44	4.84	1	50
Income (MVR)	13820	21468	0	175000
Children	0.61	0.96	0	4
Time living on island of residence (years)	19.86	12.40	1	63

b) Age distribution

Range	16-25	26-35	36-45	46-55	56-63
	56	67	37	21	11

c) Gender

	Male	Female
Gender	86	106

d) Yes/no questions

	Yes	No
Married	109	82
Does the spouse live on the same island	63	19
Employed	139	53
Land owner	56	136

e) Maximum attained level of education

	7^{th} Grade	O-level	A-Level	Diploma	1^{st} Degree	Masters	PhD
Education	7	36	34	28	65	21	1

f) Relation to head of household

	Head of household	Spouse	(step)child	Other relative	Other
Relation to head of household	44	33	28	44	43

g) Occupation

	Govern-ment	Education	Industry	Tourism	Construction	Fishing	Other
Occupation	28	37	8	20	14	1	72

5.7.1.2 Opinions about place of residence

Individuals compare potential migration destinations with their current place of residence. The importance of different factors in developing an attitude to migration behaviour depends on how people rate their current lives and place of residence. Figure 5.3 contrasts the opinions of people residing in Malé and on other islands. Malé residents rate their island higher in terms of income, education, and healthcare, compared to people living on other islands. However, people living on other islands rate their island of residence higher in terms of social environment, mentality, and general happiness, compared to residents of Malé. Residents of Malé rate Environmental Factors similarly compared to residents of other islands, except for question 2, 3, and 5, which correspond to nature and space, quietness, and population density respectively. Nature and space and quietness are rated lower in Malé, and people are more concerned about population density (question 5). Questions 1-7 in the *EA* category (see Table 5.1) are shown in Figure 5.3, questions 8-15 relate to climate change and are described in more detail in Table 5.3. Further, people outside of Malé have lower intentions to migrate internationally, but higher intentions to move internally, as compared to inhabitants of Malé.

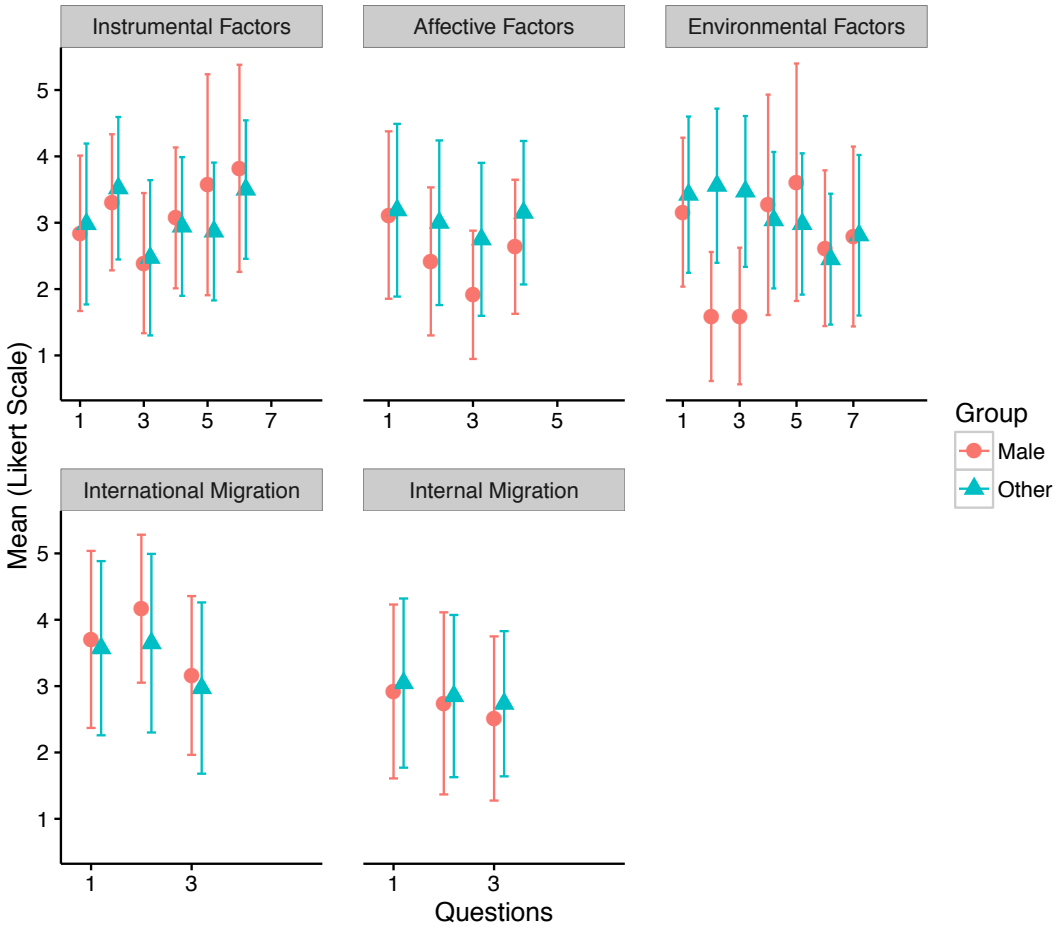

Figure 5.3 Mean and standard deviation of questions and statements regarding place of residence in five different categories. The questions and statements are all based on 5-point

Likert scales. Higher values indicate more positive attitudes to migration behaviour. The question numbers correspond to those in Table 5.1.

The wording of questions with regards to climate change is of great importance (Rudiak-Gould, 2012). Respondents are worried about the impacts that climate change and sea-level rise will have on their islands (see Table 5.3). Most respondents think that both sea-level rise and climate change will significantly impact their island (reporting either “very” or “extremely” categories) and that these impacts will affect their life significantly in the future. However, most respondents find that sea-level rise and climate change does not affect their daily life currently, nor do they feel that current environmental problems make life more difficult.

Table 5.3 Opinions about environmental change, the shade of red describes the share of respondents filling in respective answer.

Questions	1 Not at all	2 Slightly	3 Moderately	4 Very	5 Extremely
How much do you think climate change will impact this island?					
Do the effects of sea-level rise affect your daily life?					
Do you think sea-level rise will affect your daily life in the future?					
Do the effects of climate change affect your daily life?					
Do you think climate change will affect your daily life in the future?					
Environmental degradation/erosion is a problem					
Environmental problems in the place I live now make life hard for me					
Does the threat of storms or other extreme events worry you?					
Scale (%)	0	5	15	25	35

5.7.1.3 Migration intention

Intentions to move internally and internationally were both measured on a Likert scale using three questions (Q1: “Do you intent to migrate?”, Q2: “I would like to migrate to another island/country”, and Q3: “I will migrate in the coming two years”). Figure 5.4 shows that the respondents have a high intention to move internationally. Seventy-seven per cent of the respondents indicated that they either “agree” or “strongly agree” with the statement that they would like to migrate to another country. Further, there is a gap between respondent’s stated desires and expectations of actual future behaviour. Where 77% indicated they would like to move to another country, only 26% expect they will migrate in the coming two years. This percentage however, still indicates the high intention of the respondents to migrate internationally and their expectation to do so. Although it is well-known that there is a large gap between migration intention and behaviour, intention is a good indicator for future migration behaviour (Dalen and Henkens, 2008; Groot et al., 2011).

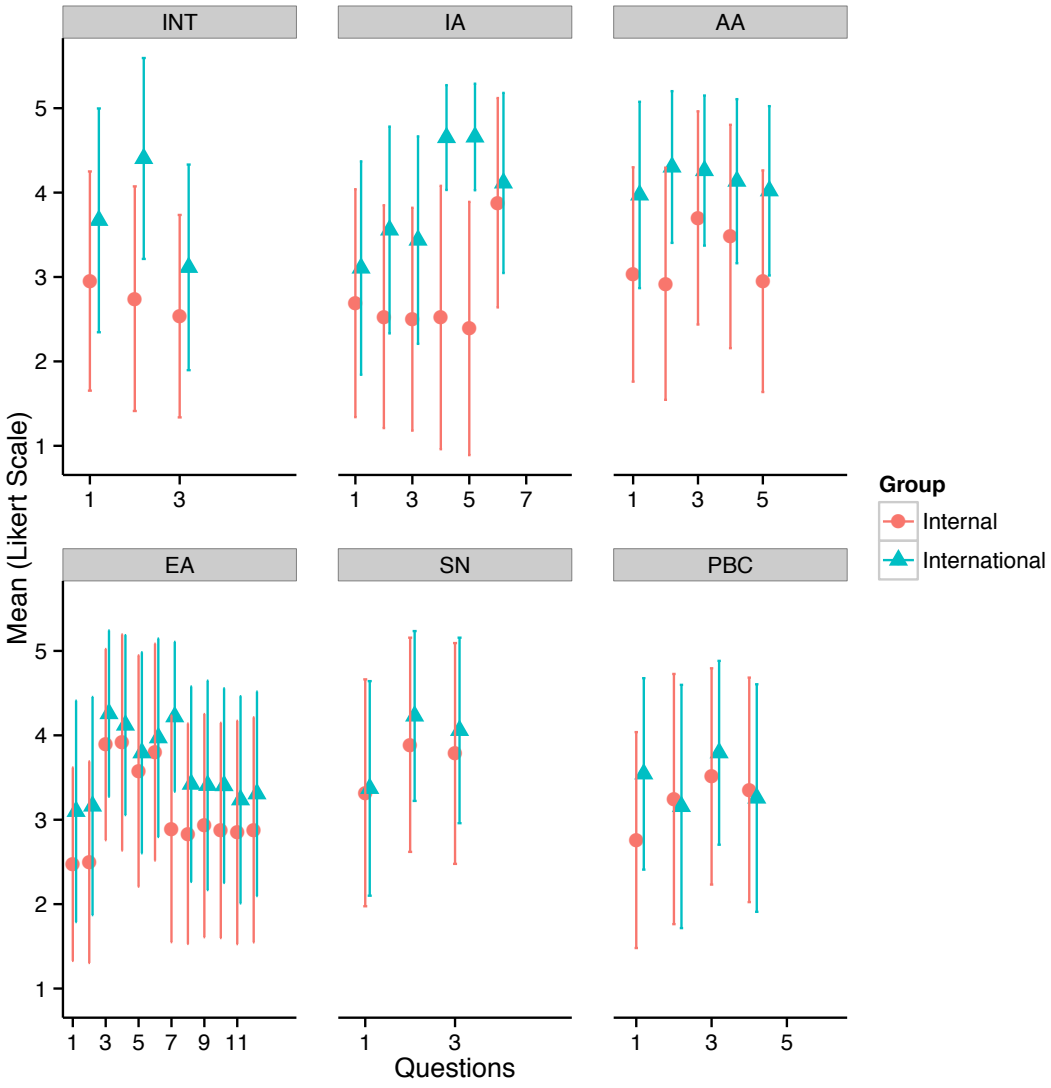

Figure 5.4 Mean and standard deviation of questions and statements in six different categories of the Theory of Planned Behaviour. The questions and statements are all based on 5-point Likert scales. Higher values indicate more positive attitudes to migration behaviour. The question numbers correspond to those in Table 5.1.

5.7.1.4 Expectations about migration

Respondents have high expectations about employment and educational prospects, healthcare, but also general happiness, social environment, and general quality of life if they migrate (see Figure 5.4). Expectations in the *IA* and *AA* categories are higher for international migration compared to internal migration. Differences between expectations about internal and international migration are less pronounced for questions in the *SN* and *PBC* categories. The *EA* category consists of questions related to the expected difference in environmental problems at the island of origin and the island/country of destination and to what extent these factors play a

role in their considerations about migration. Most environmental arguments are rated higher for international migration compared to internal migration.

5.7.2 Regression model

Results of the general linear regression models predicting migration intention for both internal and international migration are presented in Table 5.4. Background factors such as age, gender, marital status, land ownership, and level of education that are important in migration studies in small island settings in the Pacific and Caribbean (e.g. Birk and Rasmussen, 2014; Chandra, 2004; Sofer 1993) were not significant in the regression analyses presented in this study. However, these factors are *mediated* through the *IA, AA, SN,* and *PBC* variables. In regression analyses performed without the attitudes to intention, most background factors are significant predictors. This shows that the attitudes of individuals also *reflect* their background characteristics such as age, level of education, and income. Therefore, the findings in this research support the findings of the studies mentioned above.

The most mentioned factor in research about migration in a small island setting are perceived employment and educational possibilities (e.g. Brown and Connell, 2006; Guan and McElroy, 2012; Lincoln, 2009; Thomas-Hope, 1993). The *IA* variable describes these determinants and is important in predicting levels of intention to migrate in the Maldives. The *AA* variable, which is related to a positive feeling about migration such as lifestyle, general quality of life, culture, and feeling of security, is influential both in this study and in studies of Pacific islands (e.g. Connell, 2014; Shenn and Binns, 2012). *SN* further explains migration behaviour, measured by determinants such as migrant networks, and opinions of family and friends, and has low significance in predicting internal migration and higher significance in the regression model predicting intention to international migration. These findings are in line with those presented in the systematic literature review (e.g. Speelman et al., submitted-a) (see Chapter 3). The factor of *PBC* was not explicitly included in studies of the systematic review, but is an influential predictor of migration intention in the Maldives.

Table 5.4 Results of the generalised linear regression models prediction migration intention.

	Internal migration intention			International migration intention		
Variables	b (N=167)	Standard Error	Sign	b International (N=124)	Standard Error	Sign
Intercept	-1.161	2.611		3.187	2.616	
Age	0.0750	0.0413	*	-0.0259	0.0478	
Gender (Male)	-0.3677	0.491		-0.3897	0.479	
Marital status (Yes)	-0.3565	0.586		-0.2356	0.654	
Number of Children	0.2027	0.401		0.0453	0.406	
Household size	0.1209	0.0499	*	0.0035	0.0448	
Land ownership (Yes)	-0.1124	0.586		-0.5742	0.604	
Income	-1.810E-5	1.934E-5		-6.065E-6	1.240E-5	
Work (Yes)	-0.0159	0.725		-0.6399	0.728	
Occupation						
-Construction	0.4170	1.446		0.0940	1.393	
-Education	0.1259	1.215		0.6126	1.094	
-Government	0.9629	1.371		0.361	1.215	
-Industry	3.661	1.653	*	-0.3157	1.613	
-Tourism	1.355	1.445		0.9360	1.361	
-Other	0.4799	1.248		-0.2906	1.177	
IA	0.1371	0.0455	**	0.193	0.0654	**
AA	0.2486	0.0490	***	0.530	0.0731	***
EA	0.0207	0.0276		0.0290	0.0291	
SN	-0.173	0.0579	*	-0.247	0.0812	**
PBC	0.0581	0.0192	**	0.304	0.0702	***

$p \leq 0.05$; *
$p \leq 0.01$; **
$p \leq 0.001$ ***

The estimated coefficients may be interpreted in the following way: Higher *IA* to migration behaviour corresponds to a higher intention (*INT*). This indicates that if a person has higher expectations regarding, for example, educational or employment prospects abroad or on a different island, the person is likely to have a higher intention to migrate. The same holds for the positive coefficients of *AA* and *PBC*. In contrast, people who place a higher value to being with family or who experience higher family pressure (*SN*), have a lower intention to migrate.

5.8 Discussion

This section explores the different factors that influence the way Maldivians shape their intention to migrate both internally and internationally and discusses the role of perceptions about

environmental change. The discussion is based both on the data described in Section 5.7 and the statements made by respondents during the fieldwork and in the open questions (numbered 1 to 16).

5.8.1 Internal migration and the role of Malé

The analyses show that the affective attitude and instrumental attitude to migration, social norms, and perceived behavioural control are important in describing intentions for both internal and international migration.

There is a strong dichotomy between the capital island Malé and its environs and other islands. Malé is rated higher than other islands in terms of economic, health and educational opportunities. This is why people migrate there, a view strengthened by the importance of instrumental attitude in the regression analyses. Many respondents noted that Malé is the only place where there are opportunities for a career, appropriate medical facilities, and educational opportunities and is therefore, together with the neighbouring Hulhumalé, often mentioned as the only possible island to live on or to migrate to within the Maldives. This is further illustrated by comments of three interviewees:

[1] “Migrating from my current island to another island in the Maldives doesn't really apply since I'm currently living in Malé and have been all my life”.

[2] “All in all Malé city is my island, and its the only place where three education institutes and healthcare are available. So I don’t think even if I want to move to an island that it’s a choice I can make due to lack of these things and the travel!”.

[3] “Population and pollution doesn't seem be that much of a concern for people migrating here because they just don't have any other choice if they want a good education for their children and better earning jobs for themselves.”

The capital city of Malé is rated low in terms of social environment, living conditions, population pressure and living costs, and residents experience lower levels of happiness compared to other areas in the Maldives. Statements by five interviewees support this view, for example:

[4] “Malé city is overcrowded and government is actually encouraging islanders to move to Malé city. Education, employment and health facilities are so low on the other islands; people are forced to move to Malé city. Hulhumalé was supposed to be developed to decrease the population of Malé city but again islanders are moving there. Crime rate is so high. The whole youth is on drugs. Malé city is full of air pollution with hundreds of motorbikes and taxis and cars.

I love my country but hate living here. I don't have a choice as my family and friends don't want to move".

The dichotomy between economic and educational opportunities, availability of health services, and quality of life results in a situation where many respondents say they prefer to live on other islands with a relatively high population such as Fuvahmulah or in Addu City if there would be adequate opportunities, which is demonstrated by the importance of *AA* in the regression analyses. One interviewee summarised this view:

[6] "I think people in Maldives migrate due lack of healthcare, education and job opportunities at their home island. If the government can provide all these, people will be happy to stay at their home island".

The current large investments in the Hulhumalé extension, the plans of the government to invest in a bridge connecting Malé and Hulhumalé and to add a second runway to the Indira Gandhi International Airport close to Malé all show that the (perception of) employment opportunities, educational facilities, and healthcare are unlikely to change in the near future. However, there are many Maldivians who feel that there should be additional investments outside Malé to spur development on other selected islands across the Maldives, which would reduce population pressure on Malé. One respondent stated:

[7] "I believe that decentralisation is important. Hence people will migrate not only to Malé, but to different areas of the Maldives as well, which will develop the Maldives as a whole".

It is unclear if the Hulhumalé extension will provide the much-needed release of population pressure on Malé, as internal migration pressures remain high and the future numbers of guest workers is uncertain. Between 2006 and 2014 the population of Hulhumalé, Villingili, *and* Malé all increased significantly. This suggests no relief for Malé. In fact there may even be competition between the two islands, with Malé increasing building heights to allow population to expand. Hence, the Hulhumalé reclamation project rather acts as an *extension* of Malé rather than as an alternative migration location. Population pressure in Malé is only likely to decrease if additional educational and employment opportunities are offered throughout the nation and potential migration destinations are also developed in terms of quality of life, healthcare, and social environment.

These issues of equitable development are similar between the small island states (see section 5.4). The capital cities have important social, economic, and political functions and attract migrants from more rural, less populated islands. For example, the capital of Tuvalu, Funafuti, has a population of 6,194 in 2012 (UNFPA, 2012), 57 per cent of the total population. In Kiribati the

capital city South Tarawa experiences similar strong population and development pressures as Malé in the Maldives, with a population of 50,182 in 2010, 52% of the countries' population (e.g. Elrick-Barr et al., 2015). In Tuvalu and the Maldives the high rate of urbanisation has resulted in high population pressure and land reclamation in proximity to the capital islands. In contrast, the capital islands of Vanuatu and the Seychelles experience similar urbanisation, but as the capital islands are larger (non-atolls) the pressure on land availability and related influence on quality of life is smaller.

5.8.2 International migration

Maldivians have high expectations about international migration and have a positive perception about employment and educational opportunities abroad, as well as a perception that migration will lead to an increase in happiness, quality of life, and to live in a more pleasant living environment. Together with the positive image of life abroad, the heavy over-population and related pressures on quality of life and living costs on Malé and perceived lack of opportunities on other islands are underlying processes driving the high intention to move abroad. This is an indicator that while international migration is presently limited, it could increase significantly in the near future. Some already see an increase in international migration:

[8] "Maybe you could focus a little bit more on students my age (18 to 19) that migrate abroad for studies and never come back? I know plenty of people who do so. There are tons of people in the UK, Malaysia, Singapore, Australia",

[9] "I live in the capital of Maldives so migration within the country is pointless to me. However, migration out of the country is useful, if it is convenient for my family and myself, financially or otherwise to do so. I expect to be able to in a few years' time, financially, but that is not the only aspect".

The 2006 census indicates that the residual between population change and birth and death rates is very low (<0.05%) and no significant in- or outmigration is observed (Ministry of Planning and National Development, 2006). There is however, absence of official data of emigration and immigration to and from the Maldives, making these estimates unreliable. The low estimates of international migration indicate a large gap between migration intention and actual behaviour. Investments, (lack of) international migrant networks, policies, and other barriers limit the translation from intention to actual behaviour. These barriers are higher in comparison to the small island nations in the Pacific, where there are large migrant networks mainly in Australia and New Zealand and strong cultural and historic connections. Further, many of the small island states in the Pacific have developed strong cultures of migration (e.g. Connell, 2008). The development

of such migrant networks for the Maldives would almost certainly increase international migration flows in the near future, and international migration may be a reinforcing process.

5.8.3 Migration and the environment

Using the Theory of Planned Behaviour and introducing an *EA* variable and linking it to intentions to migrate is a new approach in a small island setting. This approach makes it possible to explicitly consider environmental change and the influence of their opinions on migration intention. This approach leads to different findings as compared to previous studies. In contrast to Locke (2009) and Shen and Gemenne (2011) who name environmental change as a driver of migration in Tuvalu, this study shows that environmental factors do not influence migration intentions both internally or internationally. This finding is consistent with Mortreux and Barnett (2009), who found that migrants do not consider climate change as a factor, nor expect climate change to be a factor in the future. People mentioned that other factors are more important in their considerations and that sea-level rise and climate change, as well as protection from storms, and levels of erosion do not play a role. However, respondents do recognise the effects of the 2004 Tsunami and resulting forced migration and community relocation. Several respondents further explain this:

[9] “Our reasons for migration, (be it an island affected by tsunami) are basic needs like education, health, protection against crime, housing, income etc. Even with the pollution, expensive living, crime rate and unpleasant housing, inadequate health facilities etc. people still choose to live in Malé by weighing the pros and cons. Hence environmental factors becomes secondary”.

[10] “Environment becomes secondary when primary needs are not provided or fulfilled”.

Even though environmental factors do not currently play a role in developing intentions to migrate, a view supported both by anecdotal evidence as well as regression analyses, Maldivians are worried about future impacts of climate change and often state that in the future sea-level rise might become a factor. Such statements are often linked to extreme changes and forced migration. For example,

[11] “We will probably be taken somewhere in the future”, and “sea-level rise will impact us greatly. We will be forced to move. When I am unsure of”.

In addition to comments about migration, respondents discussed the spread of impacts of sea-level rise and climate change in the Maldives. Several respondents noted that, as the whole of the Maldives is flat, there are no large differences between impacts:

[12] “Sea-level rise as is the sea-level rise of a couple of feet then there will be no Maldives”.

However, three respondents also described the potential differences in impacts between islands in the Maldives, related to their level of protection and development:

[13] “Most islands will face mass erosion while cities will adapt”,

[14] “In my opinion, the best way for Maldives to survive (or to survive longer) is that the general population move to designated "safe" islands purposefully re-enforced to deal with climate change”.

[15] “I don't think there is a safer island in Maldives (Malé) when it comes to sea level rising”.

Current intentions to migrate are subject to change and it is difficult to predict how perceptions and attitudes to migrate may alter in the future. The environmental attitude to migration could become more pronounced when faced with more rapid change, storms, or other adverse events. As one of the respondents stated:

[16] “If the livelihood of the people are directly affected by climate change or environmental degradation, then that may be an influential factor for migration”.

5.8.4 Limitations and recommendations

Limitations to this study can be categorised in two parts. First of all, there are limitations regarding the content of the survey. Comments mentioned several factors that they feel are important in addition to the ones mentioned in the survey. Respondents mentioned cultural differences between islands, family ties, religion and religious freedom, politics, political instability, taking care of the elderly, lack of political freedom, freedom of speech, and macro economic factors such as high import prices and living costs. Second, most subjects are from Malé and Addu City and other areas of the Maldives are under-represented. Respondents have a relatively high level of education compared to the general population of the Maldives. Further, the main age group of respondents is between 25 and 35 years old and the older generation is under-represented. However, the significance of attitudes to migration behaviour, social norms, and perceived behavioural control, and the mediation of background factors through the components of the Theory of Planned Behaviour all support the strength of the methods used, as well as the theory as a framework of studying migration. An increase in sample size and geographic spread would increase reliability, but are limited both by budget and time constraints. In addition, more consideration of guest workers and inward migration would be useful as this is currently an important driver of population growth on the Maldives.

5.9 Conclusions

Sea-level rise and climate change are clearly a threat in low-lying islands such as the Maldives and the atoll nations in the Pacific. However, understanding the vulnerability of small islands and linking sea-level rise and climate change with migration in a small island setting requires a broader scope than examining impacts of sea-level rise and climate change alone. Migration decision-making processes need to be carefully considered when assessing future demographic processes and their interaction with potential impacts of environmental change on coastal societies, including areas where these potential impacts are high. Looking at such coastal societies solely as a victim in the climate change debate neglects the range of drivers and trends that have shaped island societies to date, and will continue to shape them in the future. Climate change is an *additional* driver in this mix and a systemic analysis is required to understand its role. This research presents methods to provide such scope and analyses contemporary migration decision-making processes in a small island nation – the Maldives.

Maldivians respond to their current socio-economic situation and base their intention to migrate on perceptions of the costs and benefits associated with migration, affective attitude to migration, social pressure, and perceived behavioural control. There is a strong dichotomy between highly urbanised Malé and its environs, and other islands in the Maldives. Malé is rated high in terms of professional opportunities and healthcare, as it is the centre of the national economy, educational institutes, political power, and services. It is rated low in terms of living environment, quality of life, and general happiness compared to other islands due to its high population pressure and related problems. Despite issues regarding quality of life, investments in the vicinity of Malé, and the development of Hulhumalé in particular, indicate that "Greater Malé" will continue to grow in the coming decades. Centralisation around other population centres is also likely to occur, as land reclamation projects and the "Safer Islands" and "Population Consolidation Programme" focus on developing more populated islands. The "Safer Islands" programme and the development of Hulhumalé also demonstrate the capacity of Maldivians to adapt to rises in sea level via protection (and island construction and raising, in particular), rather than by migration.

There is a risk in the discourse about impacts of climate change on small island nations that migrants from small island nations are likely to be coined climate refugees, especially if there is a future increase of migration flows. It is however, important to consider that such flows are not influenced by climate change alone, but that decisions of individuals are rather embedded in existing attitudes and values toward international migration. Lowering barriers to migration by means of policies in anticipation of climate impacts could lead to an increase in international

migration. Such migration flows would not necessarily be caused by direct physical impacts of climate change and sea-level rise, but rather be a manifestation of existing migration intentions and lowering barriers to migration, a finding supported by Mortreux and Barnett (2009) in Tuvalu.

Impacts of sea-level rise and climate change in a small island setting will be defined both by the physical impacts and by the response and future development of its coastal societies. Its responses in terms of population movement will be non-uniform, depending on the socio-economic setting of each specific society, and very difficult to predict. This research presents a method to help provide such context and helps to embed future analyses in the Maldives in a broader scope of migration processes and decision-making. Wider analyses of this type would inform analysis of migration.

Chapter 6 Agent-based model simulations of future migration and demographic change in a small island setting

6.1 Abstract

Low-lying atoll islands are especially threatened by anticipated sea-level rise and migration is often mentioned as a potential response of coastal societies to this challenge. However, as yet, migration in small island settings is not well understood. Understanding future migration flows, including the potential role of environmental change, requires an interdisciplinary approach, focusing on environmental and socio-economic factors, and individual migration decision-making. This paper uses the Conceptual Model of Migration and explores migration within one small island nation – the Maldives. Agent-based modelling offers a method to combine individual decision-making and spatial drivers. Further, complex and potentially unforeseen interactions through the interaction of multiple agents can be identified. Agent-based simulations of internal migration from 1985-2014 are used as a basis to explore potential future migration pathways up to 2050. These are driven by consistent demographic, environmental, policy, and international migration scenarios. Under all scenarios, the capital island Malé and its environs experience a continued increase in population. The highest migration flows are the result of a scenario with high population growth, high impacts of climate change, international migration, and low government involvement. The lowest migration flows are the result of a future scenario with low population growth, low impacts of climate change, no international migration, and low government involvement. In summary, this research presents methods of exploring potential future demographic pathways, including exploring potential impacts of climate change and sea-level rise and adaptation responses, and provides a detailed example of such analysis in a small island setting.

Keywords: Migration, Climate Change, Agent-Based Models, Small Island States

6.2 Introduction

The threats of climate change and sea-level rise to small islands are well established (Nurse et al., 2014). Related drivers of risk include sea-level rise, storms, increasing air and sea surface temperatures, ocean acidification, and changing rainfall patterns. These are in turn likely to impact the ecosystems on which people living on small islands depend, including coastal erosion and inundation, salinisation of fresh water lenses, coral bleaching, changing abundance and distribution of fish species, and agriculture. Further impacts on various key economic sectors such as tourism and ports/shipping could be significant. Global analyses suggest that island regions will experience the largest relative increase in flood risk due to sea-level rise in the coming century (Nicholls et al., 1999; Nicholls, 2004) and low-lying atoll nations appear to be consistently vulnerable across a wide range of scenarios (Nicholls and Tol, 2006). These studies all demonstrate the high vulnerability of small island states and especially low-lying atoll islands to sea-level rise and climate change.

The first papers and Intergovernmental Panel on Climate Change (IPCC) assessment on climate change and its impacts on small islands in the early 1990s already suggested that sea-level rise could lead to total inundation of small low-lying islands (especially coral atolls) and mentioned migration and ecological refugees as the major potential impact of climate change for small island states (Lewis, 1990; Pernetta, 1989, 1992; Tegart et al., 1990). This view has been reiterated in all subsequent IPCC assessments (Bijlsma et al., 1996; McCarthy et al., 2001; Mimura et al., 2007; Nurse et al., 2014; Watson et al., 1997; Zinyowera et al., 1995). More recently, the potential high costs of adaptation to sea-level rise and climate change for islands was suggested as a driver of migration (Biermann and Boas, 2010; Gemenne, 2011; Nicholls et al., 2011).

However, migration is a complex process and linkages operate through a large variety of drivers (e.g. Black et al., 2011a). Understanding future migration flows, including the potential role of the environment, requires an interdisciplinary approach, as both the linkages between ecological and social systems, as well as individual or household decision-making processes must be considered. It is therefore fundamental to consider existing migration flows and contemporary migration behaviour when analysing potential future changes in migration including the potential effects of climate change. Despite the high profile of low-lying islands in the debate on impacts of climate change and sea-level rise and its potential effects on coastal societies, there have only been limited efforts to describe and analyse empirical migration behaviour on small islands. This requires advances in empirical migration research. Such advances depend on increased collection of quantitative data; adoption of sophisticated modelling approaches such as agent-based

modelling; and greater collaboration between environmental and migration researchers (Fussel et al., 2014).

Migration decisions are usually multi-causal and are shaped through individual agency. Individuals base their decision to migrate on multiple pressures and opportunities. Simulation modelling provides a method to explicitly include potential environmental influences and other structural changes to individual's decision-making processes. As such, complex and potentially unforeseen interactions through the interaction of multiple agents can be identified (Epstein, 2006). Such techniques can contribute to exploring potential future demographic pathways and provide insight in the influence of environmental and other factors upon migration flows within and between nations. This study presents an agent-based model (ABM) using the Maldives as a representative case study.

The Republic of Maldives, at 298 km^2, is the sixth-smallest sovereign state in terms of land area. The land is divided into 1,192 coral islands, of which 96% are less than 1 km^2 in area. Shallow lagoons enclosed by coral reefs surround the islands with an average height of only 1.6 meters and a highest point of 2.4 meters. Woodworth (2005) and Church and White (2006) confirmed that sea-level rise observations in the Maldives are consistent with global trends of sea-level rise. In 2006, 193 islands were inhabited and 91 islands had been developed as tourist resorts. The population of the Maldives has increased from 180,088 in 1985 to 399,939 in 2014 (National Bureau of Statistics, 2015). The population of the Maldives is dispersed. The capital island of Malé is the centre of economic development, services, and political power and it has grown to a population of about 127,079 on an island of 1.98 km^2 in 2014, resulting in a population density of 64,148 people per km^2 (National Bureau of Statistics, 2015). The neighbouring islands Hulhumalé and Vilimalé have a population of 15,769 and 7,790, respectively. Only 11 other islands have a population of over 2,500.

Previous analyses described historic flows of permanent migration in the Maldives in detail (e.g. Speelman and Nicholls, submitted) (see Chapter 4) and discussed contemporary migration intentions (Speelman et al., submitted-b) (See Chapter 5). These analyses show that the capital city of Malé dominates national migration flows. Further, even though environmental problems are already a cause of concern for many Maldivians, such considerations are, as yet, not important in their decisions about migration. In contrast to many small island nations in the South Pacific, international migration and remittances do not presently play an important role in migration dynamics for the Maldivian population, although the large number of guest workers in the Maldives are international migrants and support their own remittance economy.

This paper further explores migration processes of the Maldivian citizens within the Maldives using an ABM. The Theory of Planned Behaviour provides a conceptual model to break down the decision-making process relating to a behavioural intention. Historic migration flows in the Maldives are simulated from 1985-2014 and its results are compared to census datasets. On the basis of these simulations plausible futures of migration are explored from 2015 – 2050 using scenarios of future demographic, socio-economic, and environmental change. The wider implications are discussed.

The paper is structured as follows. First, the conceptual background to migration and the ABM is introduced. Second, the data is described and structure of the model is explained. Next, the model is validated on the basis of census data and sensitivity analyses are conducted. The scenarios are introduced and its results presented. Section 6.8 discusses them. The limitations are discussed in Section 6.9, and lastly conclusions are drawn.

6.3 Conceptual Model of Migration

Figure 6.1 shows the conceptual basis on which the ABM has been developed. Prior research showed that both the Drivers of Migration and the Theory of Planned Behaviour are helpful theoretical frameworks to study migration in small island states (e.g. Speelman et al., submitted-a; Speelman and Nicholls, submitted; Speelman et al., submitted-b) (see Chapter 3, 4, and 5). The Conceptual Model of Migration (CMM) combines the Theory of Planned Behaviour (Ajzen, 1991) and the Drivers of Migration of Black et al. (2011a) into a single framework, and builds on the work of Kniveton et al. (2012). The CCM recognises that drivers of migration influence decision-making processes and includes individual cognition based on the Theory of Planned Behaviour. The CMM consists of two parts: (1) drivers of migration, and (2) individual cognition.

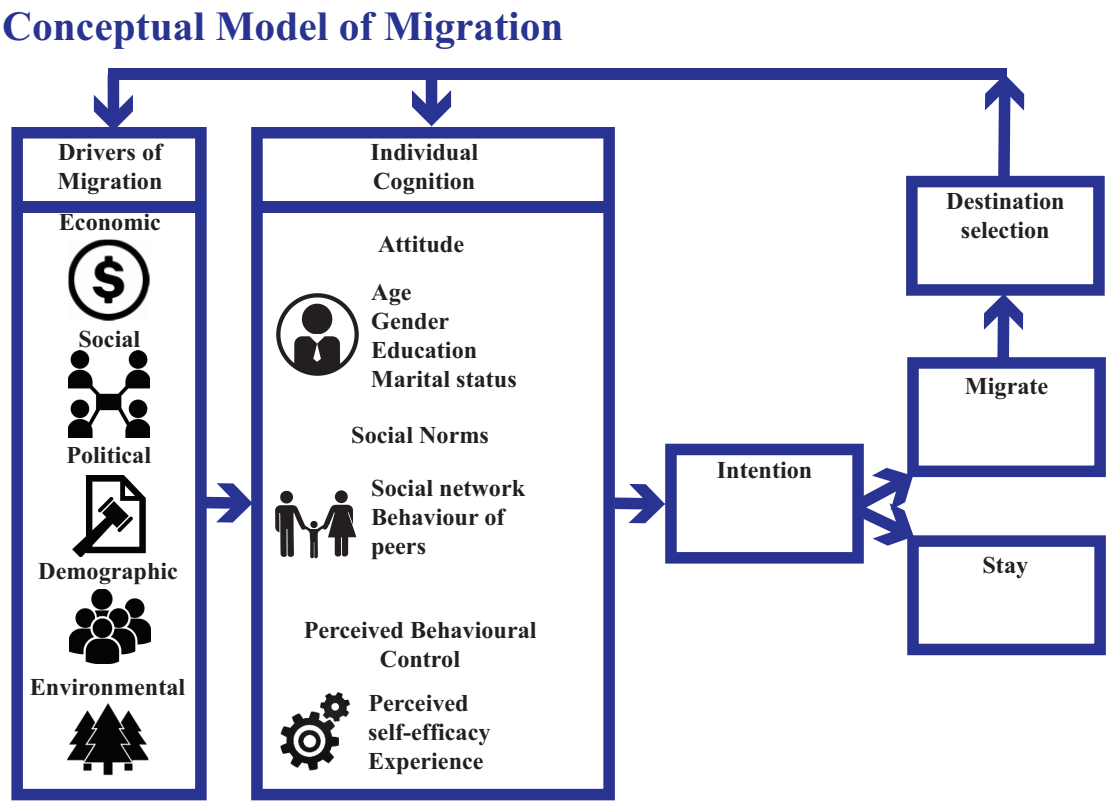

Figure 6.1 The Conceptual Model of Migration as applied to the Maldives.

Black et al. (2011a) defines five families of drivers of migration: (1) demographic, (2) economic, (3) social, (4) political, and (5) environmental drivers. The five drivers of migration have similar characteristics to push-and-pull factors as defined by Lee (1966). Demographic factors include population size and structure, birth rates, and prevalence of diseases affecting morbidity and mortality. An example of an economic driver of migration is income and wage differentials; the social driver includes factors such as family expectations and migration for educational purposes; and political drivers include the effects of policies or breakdown of governance and conflict. The environmental driver includes a population's exposure to hazard and the availability of ecosystem services. These factors are closely intertwined and should not be considered in isolation.

Although personal characteristics are included in the framework of Black et al. (2011a), the considerations of individuals and related intentions to migration and migration behaviour do not play an important role in the framework. Black et al. (2011a) explains this as follows. When people are asked why they migrated, answers almost always cluster around economic and social factors, with environmental factors rarely mentioned, even when surveys specifically ask about such factors. This empirically driven approach assumes that migrants have agency and are both self-aware in terms of their motivation for movement, and willing and able to express these motivations. Black et al. (2011a) argues that these assumptions are not necessarily valid.

In fact, most migration theories and empirical work related to migration (and the environment) largely neglect such differences and focus on larger scale movements and characteristics of place of origin and destination. However, personal background and development of attitudes to migration are important in individual considerations to migration. Understanding how individuals make decisions to migrate helps to understand how the drivers of migration interact, how they might change in the future, and are translated to higher scale migration flows.

In other research disciplines such as communication and psychology research, behavioural theories have been developed and used that help address these issues. These behavioural theories break down the development of behaviour in several components and in different layers of decision-making. An important concept in these theories is the development of an intention to behaviour. By linking the intention of an individual to several components, a researcher can assess different components to the development of intention. Such models can also be used in migration research, and have been used, although sparingly, over the past decades. In addition to the drivers of migration by Black et al. (2011a), this study addresses these issues by using the well-established Theory of Planned Behaviour (Ajzen, 1991) as a framework to analyse migration behaviour.

The theory is based on the assumption that human beings in general behave in a rational manner and that they use available information to perform (or not perform) a certain action. The theory postulates that there are three main factors influencing intention. The first factor is the *Attitude* towards the behaviour. *Attitude* describes the individual's positive or negative evaluation toward the behaviour. The second factor describes *Subjective Norms*, or the person's perception of social pressure to perform the behaviour. The third factor is the *Perceived Behavioural Control*. This factor describes the person's perceived self-efficacy or ability to perform the behaviour. If these three factors are positive, a person is more likely to have a positive intention to perform the behaviour. The importance of each factor depends on the studied behaviour. Positive intention generally translates into actual behaviour. However, obstacles such as habit formation and other environmental constraints can cause a person with a positive intention to refrain from performing the planned behaviour. In contrast, skills, knowledge, and other facilitators can have a positive effect. Implicit to the Theory of Planned Behaviour are factors influencing attitudes, norms, and perceived behavioural control. These *Background Factors* affect the motivational beliefs as postulated in the Theory of Planned Behaviour, which in turn predicts intention (see figure 1). *Background Factors* include demographic variables such as level of education, age, marital status, personality traits, and other individual differences that can influence behaviour indirectly (Fishbein, 2000). The Theory of Planned Behaviour, with the addition of an *Environmental Attitude* to migration, was used by Speelman et al. (submitted-b) (see Chapter 5) to study contemporary

migration decision-making in the Maldives in 2015 and its findings are used in this study to inform the decision-making processes of agents.

6.4 Methods

Agent-based methods offer a tool to simulate emergent migration patterns as a complex adaptive system on the nexus of climate change and demography (e.g. Kniveton, 2012). An agent-based model is a computational model simulating the actions and interactions of individual agents. By defining explicit migration decision-making processes for individuals, migration flows can be simulated. As such, complex and potentially unforeseen interactions through the interaction of multiple agents can be identified (Epstein, 2006) and therefore provides an additional valuable empirical method for analysing migration. Further, an agent-based model is able to combine different scales of analysis as postulated in the CCM. Agents interact with each other and form individual intentions to behaviour (e.g. individual cognition), and can respond to changes in their physical environment (e.g. drivers of migration).

There is a range of existing models and theories available which model decision-making processes related to adaptation and coastal processes using agent-based modelling. Existing coastal ABM models focus mostly on the interplay between coastal processes and economics (e.g. Franck, 2009; Murray et al., 2011; Lazarus et al., in press) or development of socio-economic scenarios (Fontaine et al., 2015). In addition, there is a range of models exploring the links between migration and the environment (e.g. Axtell, 2002; Kniveton et al., 2012; Kniveton et al., 2011). The theoretical foundations from these models are combined with advances in knowledge about migration described in prior work about the Maldives (e.g. Speelman and Nicholls, submitted; Speelman et al., submitted-b) (see Chapter 4 and 5) to develop a basis for agent decision-making in this model.

This paper presents a historic model on internal migration in the Maldives and uses this historic model to explore potential future pathways on the basis on a set of scenarios. Agents interact with each other and their living environment and develop intentions to migrate based on their background, networks, and living environment. The data used is described, followed by the model structure, and initialisation.

6.4.1 Data

The ABM is well grounded in data. Census data from 1985, 1990, 1995, 2000, 2006, and 2014 is used as a basis for the agent-based simulations. Aggregated data on island level, including gender distribution, population size for each island, and age structure on a national level, is available for

all datasets and this information is used to initialise and to validate the model. Data from 207 islands are included in the ABM. In addition, the 2006 census includes data on an individual level. The 2006 census dataset has been analysed in detail by Speelman and Nicholls (submitted) (see Chapter 4) and is used as a statistical basis for migration decision-making of agents.

Further, the model uses annual registered birth and deaths provided by the Ministry of Planning of the Maldives (Ministry of Planning, 2015). Future population scenarios of the Population Division of the United Nations Department of Economic and Social Affairs (DESA) are used for future scenarios (DESA, 2015).

In the ABM push and pull factors are island characteristics influencing the attitude of an agent toward migration ('push', see equation 3) and influencing the decision on where to migrate ('pull', see equation 5) and represent a combination of drivers of migration as described in the CCM. Indices for the push and pull factors are derived from an analysis performed in the Maldives on the impacts of the 2004 tsunami, measures on reported erosion events, and damages to reefs (Hameed and Coeur-Bizot, 2005); and from the Vulnerability and Poverty Assessment (VPA) carried out in 2004 in the Maldives (Hameed and Coeur-Bizot, 2004). All indices were normalised to 0 (low vulnerability) to 1 (high vulnerability). The indices were grouped in five categories (physical vulnerability, primary needs, development, services, and living environment). These indices were also used in analysing migration flows between 2000 and 2006 by Speelman and Nicholls (submitted) (see Chapter 4) and were found to add to the relationship between the sizes of migration flows between islands. To account for the relative importance of the different drivers to migration, the five categories are multiplied with their respective regression coefficient and summed (for the regression analyses, see Speelman and Nicholls, submitted (see Chapter 4)) and divided by their mean to calculate the push and pull factors (see Table 6.1).

Table 6.1 All model parameters, their values and evidence used to determine such values. If no summary statistics are provided, the parameters are dynamic.

Parameters	Description	Values	Data
O	Migration destination of an agent.	There are 3 possible destinations (1) to Malé, (2) within their Atoll District, (3) to another island.	The distinction between areas is based on analyses described by Speelman et al. (submitted) (see Chapter 4).
Age	Age of an agent	0-99.	Census data. Available for all census datasets on a national scale and on individual level for 2006.
Gender	Gender of an agent	"Male" or "Female".	Census data. Available on island scale for all census datasets and

			on individual level for 2006. Assigned randomly at birth.
Marital status	Marital status of an agent	"Married" or "Not Married".	Census data. Available on a national scale for all census datasets and on individual level for 2006. Assigned randomly at birth according to existing distribution.
Education	Level of education of an agent	0-17 (no education – PhD). See Chapter 4 for further explanation.	Census data. Available on a national scale for all census datasets and on individual level for 2006. Assigned randomly at birth according to existing distribution on island level.
migrant	A count of the number of migrants to destination *O*, with attributes *Age, Gender, Marital status,* and *Education*	Total migrants included in the database to: Malé: 15,444 Within Atoll District: 9,257 Other: 9,584	2006 census data (N=298,968). A count of the number of migrants with attributes *Age, Gender, Marital status,* and *Education* to destination *O* between 2000-2006. For a detailed analysis of the census, see Speelman and Nicholls (submitted) (see Chapter 4).
Network size	Size of social network.	50	Based on Kniveton et al. (2012). The effect of network size is additionally explored in a sensitivity analysis.
PBC	The Perceived Behavioural Control represents random personal differences between agents.	Range: 0.5-1.5 Mean: 1.0 SD: 0.25	Random distribution to account for personal differences in migration behaviour.
Push Factor	The push factor of an island influences the attitude of an agent to migrate.	Range: 0.379-1.658 Mean: 1.0 SD: 0.256	Based on vulnerability indices for the Maldives by Hameed and Coeur-Bizot (2004, 2005) and regression analyses by Speelman and Nicholls (submitted) (see Chapter 4).
Pull Factor	In addition to population size, the pull factor of an island influences the attractiveness of an island as a migration destination	Range: 0.523-1.928 Mean: 1.0 SD: 0.286	Based on vulnerability indices for the Maldives by Hameed and Coeur-Bizot (2004, 2005) and regression analyses by Speelman and Nicholls (submitted) (see Chapter 4).
Population Size	The population size of an island	-	Determined by the sum of all agents residing on the island.
Birth and mortality rates	Rate of births and deaths by year.	Birth (%): 0.74- 4.88 Mortality (%): 0.32-0.88	Historic rates: Ministry of Planning (2015). Future population growth: DESA (2015).

6.4.2 Model structure

The structure of the ABM closely follows the CCM (Figure 6.1). The central process in this model is the development of an agent's intention to migrate. The implementation of this process in the ABM is first explained. This is followed by an explanation of the processes that influence the development of an intention to migrate: (1) the formation of an Attitude (*A*) to migration based on personal characteristics of an agent, (2) the influence of Social Norms (*N*) based on the agent's social network, and (3) the Perceived Behavioural Control (*PBC*) of an agent. These processes are influenced by drivers of migration, which are represented by push factors in the ABM. If an agent decides to move, the destination is determined on the basis of population size of potential destinations and their respective 'pull' factors. Lastly, the implementation of one time step in the ABM is discussed.

6.4.2.1 Intention to migrate

Migration to Malé dominates migration flows in the Maldives and local moves within Atoll Districts also account for a large fraction of 27% of internal migration between 2000 and 2006 (Speelman and Nicholls, submitted) (see Chapter 4). Based on this distinction, agents develop intentions to migrate to three potential destinations *O*: (1) to Malé, (2) within an Atoll District, or (3) to another island in the Maldives. The chance of an agent to migrate (μ) is determined by summing the probabilities for migration for each of the destinations *O* (see equation 6.1).

$$\mu = \mu_{O1} + \mu_{O2} + \mu_{O3} \qquad [6.1]$$

A random number between 0 and 1 determines whether the agent will move. Based on a weighted choice of the respective size of μ, agents decide to move to (1) Malé, (2) within their Atoll District, or to (3) another island. After the agent decides to move within the Atoll District or to another island in the Maldives, a destination is picked from a list based on population size and the *Pull Factor* of an island, explained in section 6.4.2.4.

An agent develops an intention to migrate to destination *O* based on three factors and is defined as a probability (see equation 6.2). The first factor relates to the attitude (*A*) of an agent toward migration to destination *O*, the second to personal norms (*N*) and past migration behaviour of their peers to destination *O*, and the third to the Perceived Behavioural Control (*PBC*) of the agent.

$$\mu_O = A_O * N_O * PBC \qquad [6.2]$$

A_O is based on the personal background of the agent and on the place where the agent is residing. N_O is based on social norms and is simulated using social networks. *PBC* is included on the basis of a random factor between 0.5 and 1.5 to account for differences in personality in the population. The agent develops an intention based on these factors, resulting in a probability to migrate.

6.4.2.2 Attitude to migration

The attitude (*A*) of an agent to migrate to destination *O* compromises two factors: (1) a factor based on the personal characteristics of an agent and (2) a factor based on island characteristics where the agent is residing (*Push Factor*).

The first factor *A* represents the probability of an agent with the attributes *Age, Gender, Marital Status,* and *Education* migrating to destination *O* being considered. This probability is determined on the basis of the 2006 census (N=298,968). A dataset was constructed with individuals with the attributes *Age, Gender, Marital Status,* and *Education* and whether the individual migrated between 2000 and 2006 to destinations *O*. Detailed analyses are described by Speelman and Nicholls (submitted) (see Chapter 4). The probability value is calculated from the number of individuals within the dataset used with defined attributes *Age, Gender, Marital Status,* and *Education* who are migrating to destination *O*, divided by the population with the same defined attributes in that dataset and the number of years included in the dataset.

In addition to personal characteristics of the agent, the attitude to migration also depends on the island of residence of the agent, represented by the *Push Factor* (see equation 6.3).

$$A_O = \left(\frac{m(Age,Gender,Marital\ Status,Education,migrant)}{(Age,Gender,Marital\ Status,Education)}\right) * \text{Push Factor} \quad [6.3]$$

6.4.2.3 Social norms

The N_O component simulates the influence of peers on an individual on the development of their migration intention and is defined as pressure through a social network (see equation 6.4). If people from a simple pre-defined network migrated in the past 2 years, the agent experiences an additional pressure to migrate. Kniveton et al. (2012) used a similar approach to model social pressure. Although these simplified network neglect complex spatial and social interactions between agents, it provides a good first estimate of the effect of social networks on migration. Each agent is connected to fifty others at model start up. Information is shared about their migration moves and agents store this information for 2 years. On the basis of the information shared, a peer opinion value N_O is determined for each of the migration options *O* considered.

$$N_O = 1 + \frac{Number\ of\ migrants\ in\ network\ to\ destination\ O}{Network\ Size} \quad [6.4]$$

6.4.2.4 Destination selection

If an agent decides to move to Malé, no additional decision is required. If the agent decides to move within their Atoll District, or to another island in the Maldives, a destination island is selected. This decision is proportional to the population size, as postulated by gravity theory, and *Pull Factor* of the islands considered, see equation 6.5. For moves within an Atoll District, all islands in the Atoll District, except the island of residence and Malé, are considered. For moves to other islands, all islands, except those in their Atoll District and Malé, are considered potential destinations.

$$Island_O \propto Population\ Size * Pull\ Factor \qquad [6.5]$$

6.4.3 Model initialisation and time steps

The initial population distribution by island is based on the census dataset in which the simulation starts (i.e. 1985, 2000, or 2014). Agents are distributed according to population size and gender distribution of each island. The age of the agents is defined according to the age structure of the entire population and distributed randomly, as island-level data on age structure of the islands is not available. Only inhabited islands are included in the simulation, excluding islands with specific functions such as resort islands or airport islands.

Between 1990 and 2014, the population of 11 islands have been relocated to another island, and the population of 4 islands was relocated permanently to another island due to the impacts of the 2004 Tsunami. The Population Consolidation Programme and impacts of the 2004 Tsunami are implemented in the historic model by moving the entire population of an 'abandoned' island to a 'destination' island (see section 6.6.2).

The level of education of the agents is assigned randomly according to the 2006 census dataset. A time step, representing one year, is implemented as follows:

1. **Migration module**: Agents make a decision to move each year according to equations 1-5. All agents make their decision to migrate simultaneously.
2. **Birth and mortality module**: New agents are introduced. The number of births is based on yearly historic birth data or population scenarios. The new agents are distributed proportionally to population size of the islands and are assigned a level of education and marital status at birth according to existing distributions on their island of residence. Agents are removed from the model based on yearly mortality rates and associated distribution of deaths (e.g. mortality by age group) by year.
3. **Ageing module**: Agents age by one year.

4. **Scenario module**: Scenarios and population consolidation programmes are implemented (see section 6.6).

6.5 Model validation: Historic simulations of internal migration

To validate the ABM, simulations from 1985-2014 and from 2000-2014 are compared to observations (census data). First, model reduction is applied to assess different components of the ABM. Second, simulated population size and characteristics of islands are compared to the census datasets. Lastly, sensitivity analyses are performed for push and pull factors and size of social networks.

6.5.1 Model reduction

ABM implementations of different complexity are explored, based on model reduction. Four distinct models are analysed:

1. **Birth and mortality**. This model excludes any migration processes. Island population solely changes due to birth and mortality on the islands. This model provides a baseline for comparison of the quality of the model.
2. **Statistical ABM**. This ABM includes migration processes based on 2006 census data, but excludes push and pull factors and social networks.
3. **Push and pull ABM**. This ABM includes migration processes, but excludes the effect of social networks.
4. **Complete ABM**. This model is the ABM as described in equation 6.1-6.5.

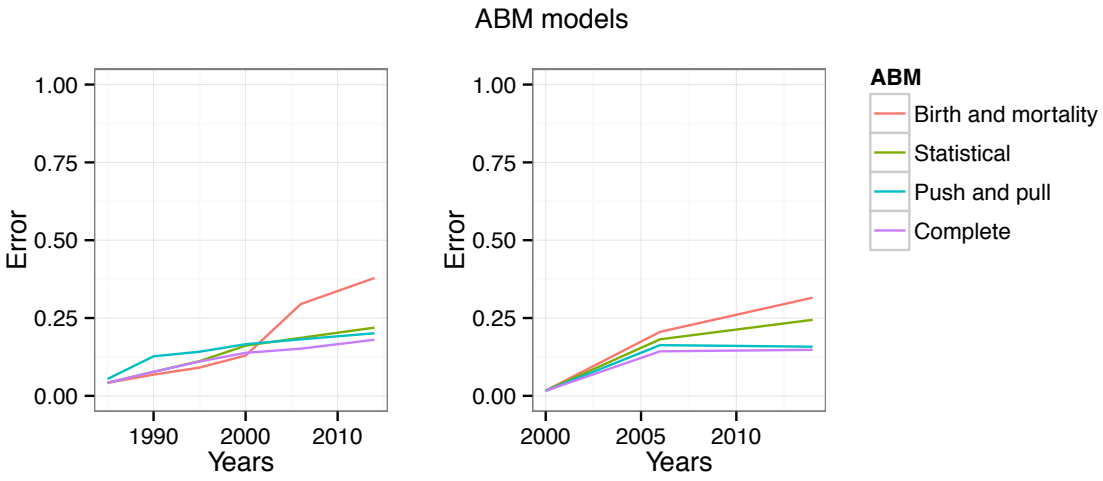

Figure 6.2 The sum of errors in population size as compared to census datasets for each island in relation to the total population initialised in 1985 (left) and in 2000 (right) for the four different ABM models.

The simulated population of each island is compared to the census population. The error is the absolute difference between simulated population size and census data. The sum of errors on all islands is compared to the actual population size (see Figure 6.2).

Figure 6.2 shows that each layer of complexity added to the model reduces the error. The Complete ABM best describes the population size of islands in 2014 as the error is reduced from 0.378 (solely based on birth and mortality rates) to 0.180 (Complete ABM) for the model runs starting in 1985, and from 0.315 (solely based on birth and mortality rates) to 0.148 (Complete ABM) for model runs starting in 2000.

This shows that migration is a significantly less important process between 1985-2000 compared to the period 2000-2014. The increase in the error from 2000-2014 in the birth and mortality ABM supports this. Possible explanations include the development of resorts, mainly around Greater Malé, and changes in the economic structure of the country.

6.5.2 Simulated population size and structure as compared to census data

The simulated output of the Complete ABM closely resembles developments in population size of islands between 2000 and 2014 (see Table 6.2). It shows that the error is greatly reduced for the 10 most populated islands of the Maldives in 2014 as compared to the model based on birth and mortality rates. The ABM slightly underestimates migration to 'Greater Malé' (Malé, Hulhumalé, and Villingili).

Table 6.2 Simulated and census population (excluding expats) in 2000 and 2014 for the 10 largest islands by population in 2014, based on simulations starting in 2000.

	Census		Simulation			
	2000	2014	2014 (without migration)	Error	2014 (including migration)	Error
Malé	67,939	109,635	84,001	-25,634	107,117	-2,518
Hulhumalé	0	14,551	4,263	-10,288	13,802	-749
Hithadhoo (Addu)	9,461	9,894	12,113	2,219	10,967	-1,146
Fuvahmulah	7,528	8,055	9,706	1,651	9,019	964
Kulhudhuffushi	6,581	8,011	8,562	551	9,466	1,455
Villingili	4,291	7,304	5,538	-1,766	6,004	-1,304
Thinadhoo	4,893	4,707	6,307	1,600	5,982	1,275
Naifaru	3,707	3,844	4,865	1,021	3,947	103
Feydhoo (Addu)	2,829	3,397	3,650	253	2,962	-435
Gan (L)	2,224	3,333	2,906	-427	4,077	744

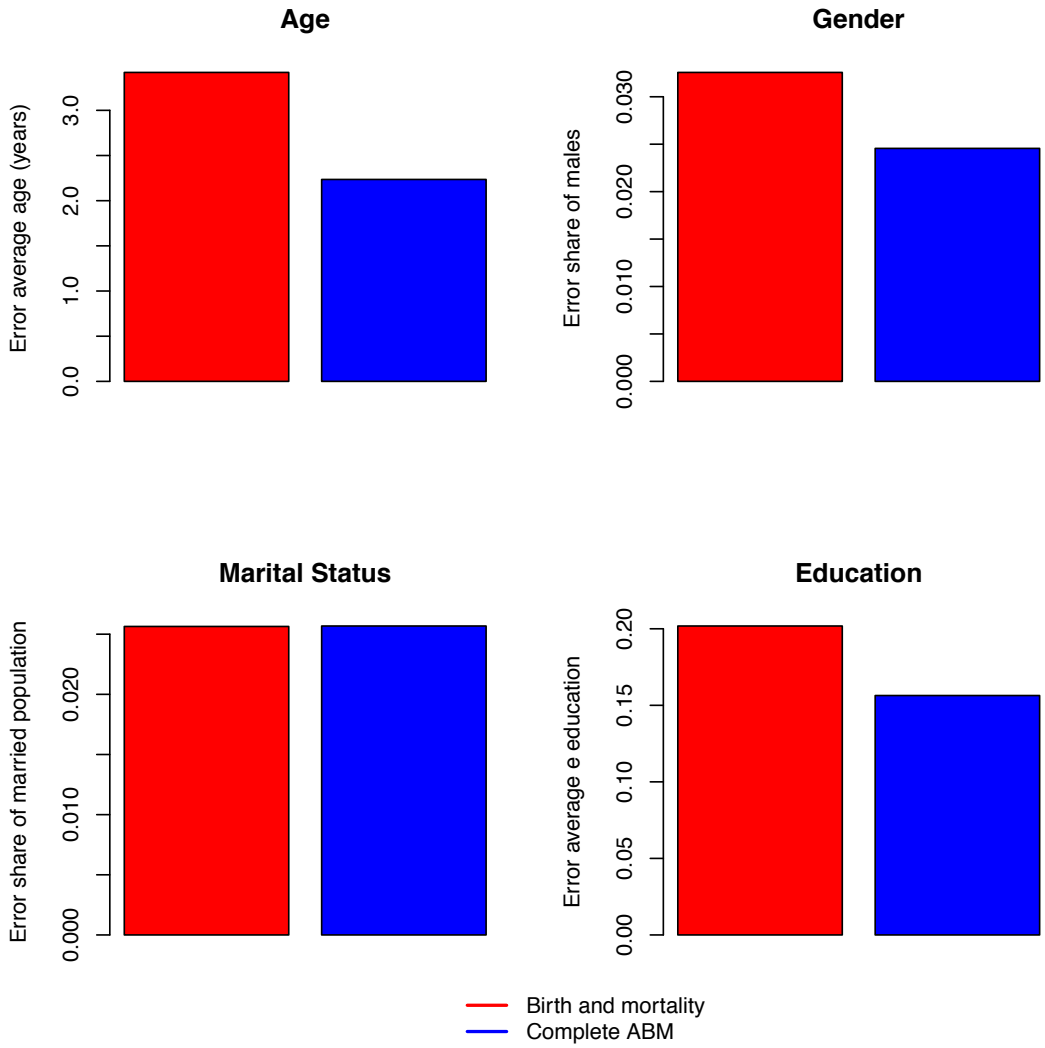

Figure 6.3 The bar plots show the average errors of average age, share of males, share of married population, average level of education, on island level for the birth and mortality model and the Complete ABM. The output of the models is compared to 2006 census data.

Figure 6.3 shows that, in addition to distribution of population over the islands, the Complete ABM describes other characteristics of the population on islands much better as compared to the baseline birth and mortality model. This shows that the migration module in the ABM results both in a better description of population size *and* structure.

6.5.3 Sensitivity analyses

The previous two sections show that the ABM simulations closely resemble developments as captured by the census datasets and that an ABM including migration processes performs better than population developments solely based on birth and mortality rates. Figure 6.2 shows that

network size and push and pull factors add to the performance of the ABM. The effects of these two processes are further explored below.

Figure 6.4 shows the sensitivity of the ABM to network size. The errors are based on simulations between 2000-2014. The sensitivity analyses show that the error is smallest for a network size between 50 and 100. As the network size increases further, the error increases. This can be explained by increasing rates of migration. For example, for a network size of 300, the estimated population of Malé in 2014 was 124,125, as compared to the census result of 109,635.

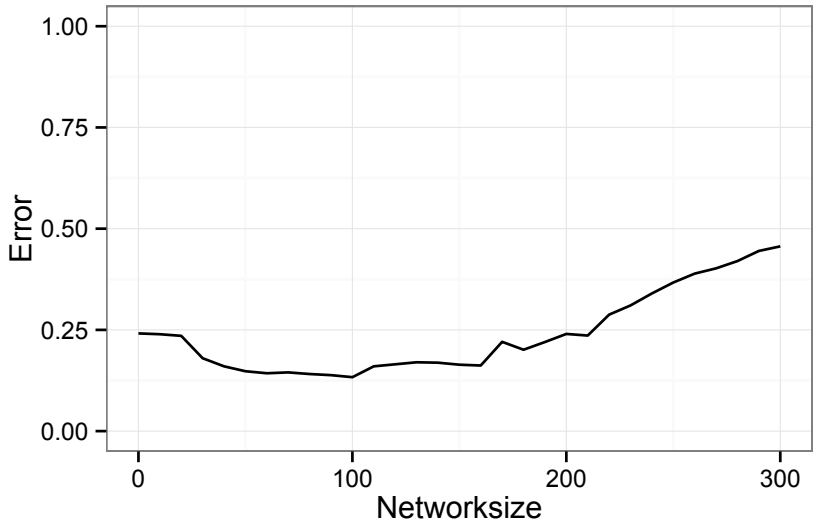

Figure 6.4 The sum of errors in population size for each island in relation to the total population for different network sizes.

In the simulation model, the push and pull factors are *static.* However, in reality push and pull factors are *dynamic* and depend on changes in investments in economy, healthcare, and education, implemented policies, natural impacts, or other factors influencing quality of life on the islands. The sensitivity of the model to these factors is further explored in the implementation of scenarios. Figure 6.5 shows the sensitivity of the ABM to the total size of, and differentiation between, push and pull factors.

The sensitivity analyses are based on runs from 2000-2014 and a subset of agents (10,000). Push and pull factors for each island are increased or decreased by a random percentage individually, where the x-axis represents the average percentage of change. The y-axis represents the average increase in size of push and pull factors as compared to the Complete model. An increase in the size of all push and pull factors amplifies the differences between islands, resulting in larger migration flows (and vice versa). Changes in the differentiation of push and pull factors results in a different relation between the islands and changes the size *and* direction of migration flows. The

error represents the sum of errors of the (scaled) population size of each island as compared to the 2014 census results. The maximum possible error is 2.

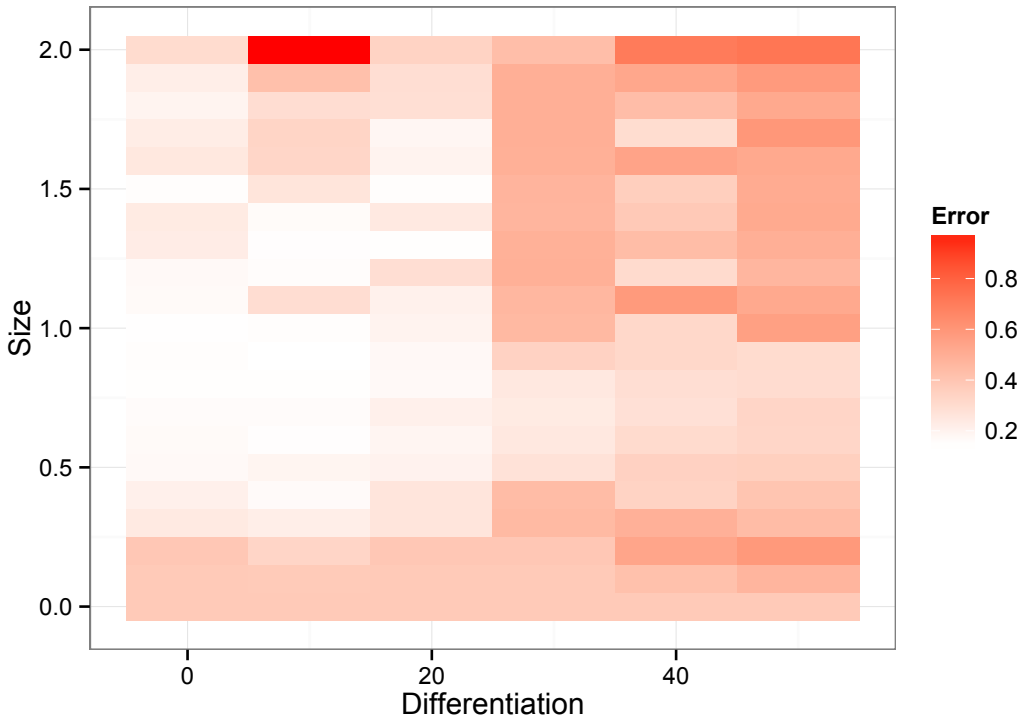

Figure 6.5 Push and pull factors are increased or decreased by a random percentage for each island individually, where the x-axis represents the average percentage of change as compared to the push and pull factors based on vulnerability indices. The y-axis represents the average increase in size of push and pull factors as compared to the Complete model. The shade of red illustrates the error as compared to census data.

Figure 6.5 shows that the push- and pull factors based on the vulnerability indices provide a good solution as compared to the other implementations of the ABM. As a random process determines the changes in differentiation of push and pull factors, the exact errors will differ for each implementation. It is likely that there are distributions that would better fit the output of the model. However, in the results presented below, the push and pull factors are implemented on the basis of data, rather than optimisation methods of fitting the output to the census data.

If the total size of the push and pull factors is greatly decreased, the results converge to the error of the birth and mortality module, as migration plays a marginal role in the ABM. Further, this analysis shows that changing relations and development between islands, represented by changing push and pull factors, can cause significant changes if certain thresholds are reached. The figure however, also shows that without large changes in both differentiation and size of push and pull factors, such extreme developments are unlikely.

6.6 Scenarios

The future scenarios presented in this model consist of 6 narratives for future development of the Maldives, as described in Table 6.3. The scenarios are based on the narratives developed as part of the UK Foresight project on migration and global environmental change (Government office for Science, 2011), with the inclusion of two additional intermediate scenarios.

Table 6.3 Six narratives for future population development in the Maldives to 2050.

Scenario	Narrative	Demographic	Environment	Governance	Globalisation
A	High global growth in a globalised world, and inclusive local social, political and economic governance.	High	High	Inclusive	Global
B	High global growth in a globalised world, and exclusive local social, political and economic governance.	High	High	Exclusive	Global
C	Low global growth focusing on local development, and exclusive local social, political and economic governance.	High	Low	Exclusive	Local
D	Low global growth focusing on local development, and exclusive local social, political and economic governance.	Low	High	Exclusive	Local
E	Low global growth in a globalised world, and inclusive local social, political and economic governance.	Low	High	Inclusive	Global
F	Low global growth focusing on local development, and exclusive local social, political and economic governance.	Low	Low	Exclusive	Local

The scenarios provide examples of possible future pathways and are not predictions; their purpose is simply to propose contrasting but plausible ways in which political and economic factors would combine to influence migration (Government Office for Science, 2011). These scenarios are implemented based on four different processes interacting with migration: (1) demography, (2) environment, (3) governance, and (4) globalisation. The implementation of the scenarios in the model is discussed below (see Table 6.4).

Table 6.4 Implementation of the narratives in Table 6.3 as inputs to the ABM models (to 2050).

Parameters	Description	Implementation	Source/comment
Demographic	Two scenarios of population growth are implemented.	Low: Total population of 426660 in 2050 High: Total population of 561680 in 2050	Population Division of the United Nations Department of Economic and Social Affairs (DESA, 2015)
Environment	Describes impacts of environmental change by means of its effects on the drivers of migration, represented by push and pull factors in the ABM.	Low: None High: Each time step, 10 randomly selected islands experience an increase of 10% of their *Push Factor*	Arbitrary increase of 10%. The increase in the push factor is not a prediction, but rather an *illustration* how changes in drivers of migration due to environmental change (including climate change) can potentially influence migration flows.
Governance	Governance describes the role of the government in population policies and adaptation to climate change.	Exclusive: None Inclusive: The 10 most populated islands (in 2014) are protected from environmental change. Islands with a population of <50 are relocated to islands in their Atoll District.	Builds on the existing 'population consolidation' and 'Safer Islands' policies of the government of the Maldives.
Globalisation	High globalisation results in larger international migration flows.	Local: None Global: International migration flow of 10% of the size of internal migration flows.	The distribution of international migrants is based on Speelman et al. (submitted-b) (see Chapter 5). The size of international migration is arbitrary, as there has been negligible international migration from the Maldives.

6.6.1 Demography

The Population Division of the United Nations Department of Economic and Social Affairs (DESA) has developed population growth scenarios up to 2100 (see Figure 6.6). The projections are based on estimated fertility and mortality rates based on female and male life expectancy and estimated international migration. Official historic international migration estimates are negligible for the Maldives and thus do not play a role in the population projections. This research explores two population projection scenarios. The low population projection results in a peak of population of 429,740 in 2045 and declines to levels below 2014 in 2072 and the high scenario projects population to continue to increase until 2100, up to 668,000. The simulations presented in this

paper run up to 2050, where the difference between the low and high growth scenarios is 135,000 people.

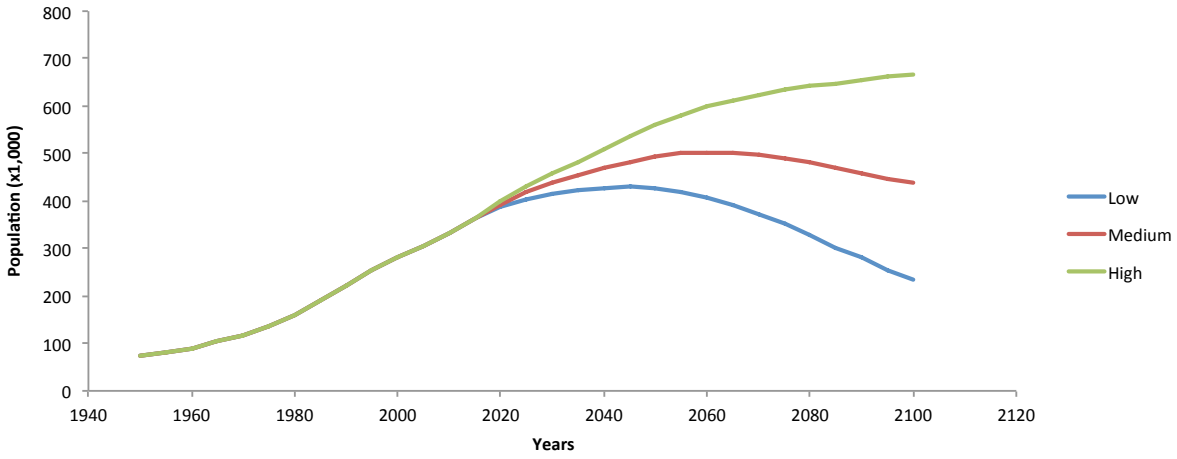

Figure 6.6 Population projection of the Maldivian population (DESA, 2015).

6.6.2 Governance

The government of the Maldives initiated the Population Consolidation Programme to (1) develop stronger regional centres, (2) reduce the dispersion of population over the archipelago, and (3) reduce the associated costs of development (Ministry of Planning and National Development, 2004). The principles of the Population Consolidation Programme can be extended to potential investments and migration policies in adaptation to climate change, and on the basis of this premise, the government of the Maldives developed the Safer Islands strategy. The "Safer Islands" are designated islands that are relative large and better protected from natural disasters, where communities from smaller, more vulnerable islands can be resettled (Ministry of Environment, Energy, and Water, 2007). The effects of the Population Consolidation Programme and Safer Islands programme on distribution of population are explored in the ABM. These are implemented as follows. At each time step, islands with a population larger than 50 are relocated to a higher populated island nearby. Further, the 10 most populated islands (in 2014) are protected from environmental change.

6.6.3 Environment

Climate change is likely to impact the ecosystems on which people living on small islands depend (Nurse et al., 2014). These impacts are likely to differ for each island and society. The Drivers of Migration framework of Black et al. (2011) postulates that impacts of environmental change influences the five families of drivers. In the ABM these are represented by the push and pull

factors of islands. Exact impacts for each island and its interaction with the drivers of migration however, are not well understood. In this research impacts of environmental change are linked to increase in push factor of islands. For each time step, 10 randomly selected islands experience impacts of environmental change by an arbitrary increase in their push factor of 10 per cent. The increase in the push factor is not a prediction, but rather an *illustration* how changes in drivers of migration due to environmental change (including climate change) can potentially influence migration flows.

6.6.4 Globalisation

Speelman et al. (submitted-b) (see Chapter 5) shows that Maldivians have high expectations about international migration. Young and high-educated people have higher intentions to migrate internationally. Removing barriers to international migration by, for example, the development of migrant networks or changes in policies, could lead to an increase of international migrants. In the ABM simulations this potential future development is linked to globalisation processes. In a more globalised world, policies regarding international (environmental and economic) migration are likely to be less stringent. Based on this assumption, agents in the ABM consider international migration based on the distribution of international migration intentions by age, gender, level of education, and marital status from the survey data used by Speelman et al. (submitted-b) (see Chapter 5). A dataset was constructed based on five age groups, 3 groups of levels of education, gender, and marital status and respective intentions to migrate internationally. First, a combination of age, gender, level of education, and marital status was selected on the basis a weighted choice of migration intentions. Second, international migrants were selected by random choice from that group.

The size of the migration flows however, is very difficult to assess, as data of historic international migration is lacking and is represented by an arbitrary value of 10% the size of internal migration flows in this ABM. However, the spatial distribution of potential international migrants and its interaction with other (migration) processes in the ABM *can* be explored.

6.7 Results

The scenarios describe plausible quantitative futures of demographic change in the Maldives. Table 6.5 and Figures 6.7, 6.8, 6.9, and 6.10 provide a summary overview of the developments in terms of population growth, distribution, island abandonment, and size of migration flows.

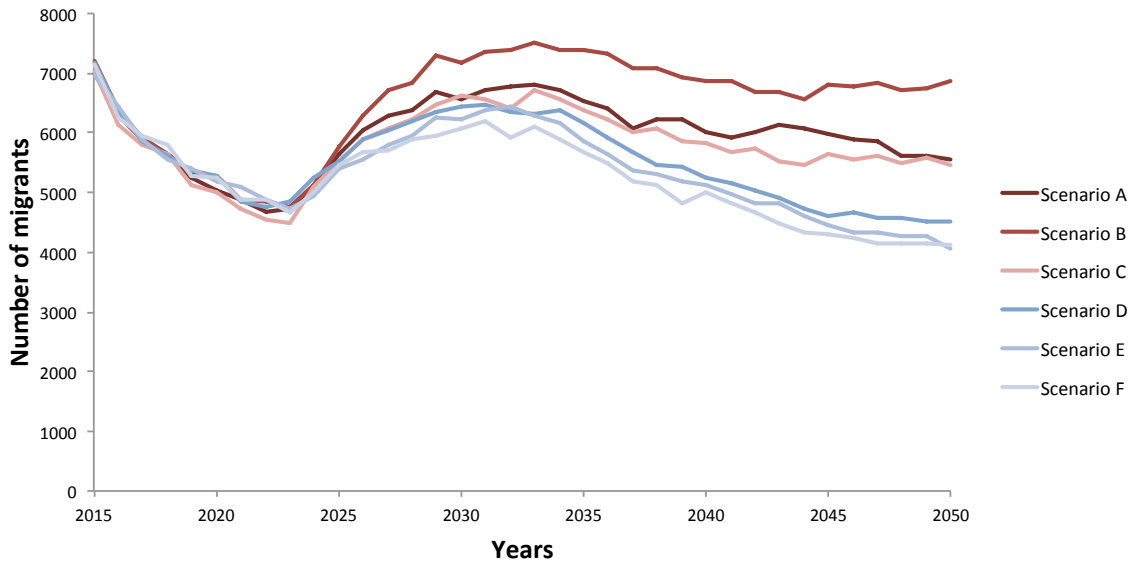

Figure 6.7 Number of migrants per year for scenario A to F.

The initial decrease in migration between 2015 and 2023 is caused by a sharp decline in birth rates between 2000-2006 and the increase in migration between 2023-2030 due to a steady increase of birth rates from 2006-2014 (see Figure 6.7). Migration to Malé and Hulhumalé dominates both the high- and low population growth scenarios. Whilst population growth slows down on a national level in the low population scenarios, population increases on both Malé and Hulhumalé (see Table 6.5 and Figure 6.8). This results in rapidly declining populations on many other islands. For example, in 2050 under scenario F, there are 24 islands with a population of 50 or less, and 43 with a population of 100 or less. In the corresponding Scenario C, based on high population growth and excluding other factors, there are 19 islands with a population of 50 or less, and 38 with a population of 100 or less. In practice, many of the islands would be abandoned if this was realised.

This shows that both the high and population growth scenarios result in rapidly declining populations on less populated islands. This is further illustrated in Figure 6.10, where the majority of islands experience negative population trends in both the low- and high population growth scenarios and in Figure 6.9, where the number of islands with a population of <1000 increases in scenario A to F consistently. All scenarios result in explosive growth of the population on Malé and Hulhumalé. The high population growth scenario results in more migrants (Figure 6.7) and a much higher population on Malé and Hulhumalé. Further, the high population growth scenario results in a slight population growth or stable population on other relatively high-populated islands, as compared to declining populations on these islands in the low population growth scenarios (see Table 6.5). This includes Villingili, a neighbouring island of Malé. Hulhumalé is more attractive as an alternative destination to Malé for Maldivians. This is effect is reinforced in the

ABM by the increasing in population of Hulhumalé. This corresponds to findings as presented by Speelman et al. (submitted-b) (see Chapter 5), where Hulhumalé, in contrast to Villingili, is often mentioned as an alternative for Malé.

Table 6.5 Population size of the 10 islands with highest population in 2014 for all scenarios in 2050.

Islands	Census		A	B	C	D	E	F
	2000	2014	2050	2050	2050	2050	2050	2050
Malé	67,939	109,635	217,976	223,278	228,384	168,330	154,949	169,819
Hulhumalé	0	14,551	118,411	128,177	136,282	97,814	91,297	92,614
Hithadhoo (Addu)	9,461	9,894	9,899	7,875	8,051	6,613	6,765	6,862
Fuvahmulah	7,528	8,055	8,666	7,319	7,169	5,612	5,858	5,872
Kulhudhuffushi	6,581	8,055	10,291	8,395	8,842	7,032	6,960	6,801
Villingili	4,291	7,304	8,061	6,446	6,847	5,164	5,521	5,567
Thinadhoo	4,893	4,707	5,004	3,999	4,165	3,148	3,464	3,335
Naifaru	3,707	3,844	3,076	2,329	2,453	2,009	2,014	1,977
Feydhoo (Addu)	2,829	3,397	2,768	1,985	2,141	1,545	1,846	1,706
Kandoodhoo	2,224	3,333	5,260	5,113	5,042	3,611	3,809	3,796

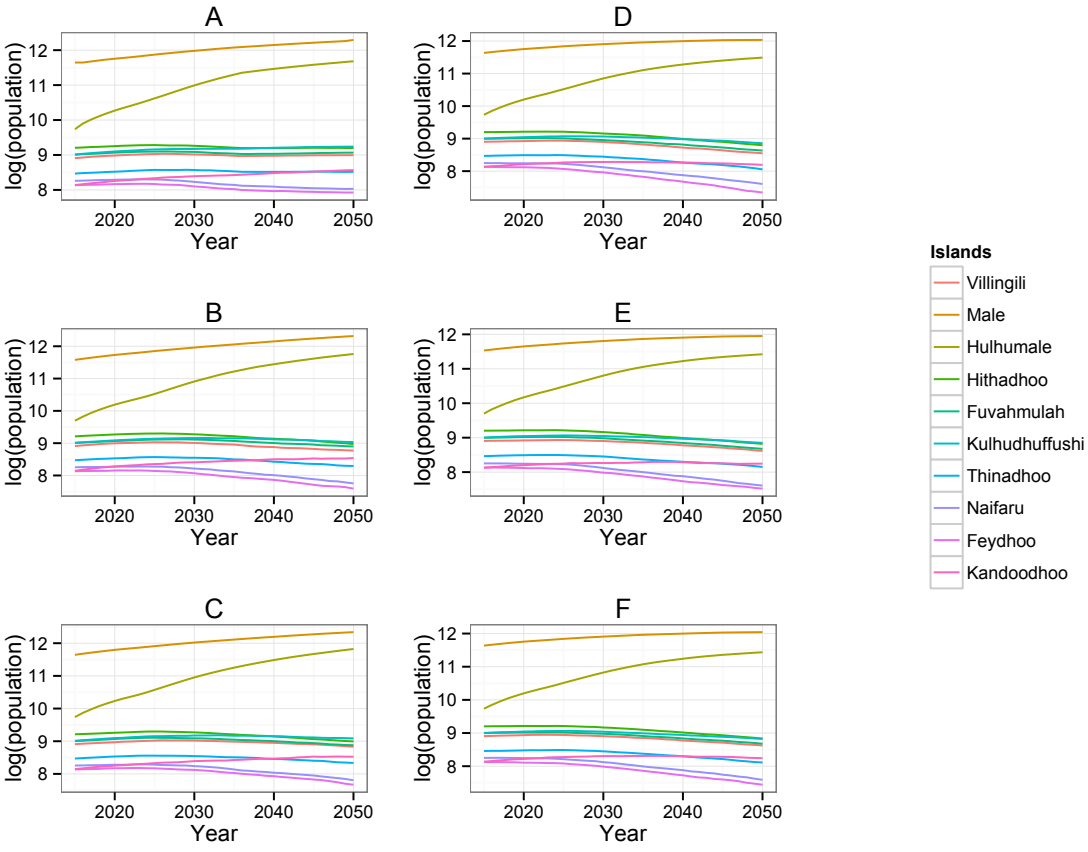

Figure 6.8 Logged population size of the 10 most populated islands in 2014 for scenario A to F.

Impacts of climate change as implemented in the ABM increase the size of migration flows *and* change migration patterns between islands. The exact patterns depend on the respective impact of environmental change. The ABM simulates environmental change on the basis of relatively small impacts on push factors of islands. This represents changes in island characteristics, such as professional opportunities, services, and quality of the living environment. There is some differentiation between the different scenarios including environmental change depending on the distribution of impacts, which is simulated by a random process in the ABM and hence the output of the ABM will differ for each specific implementation of environmental change.

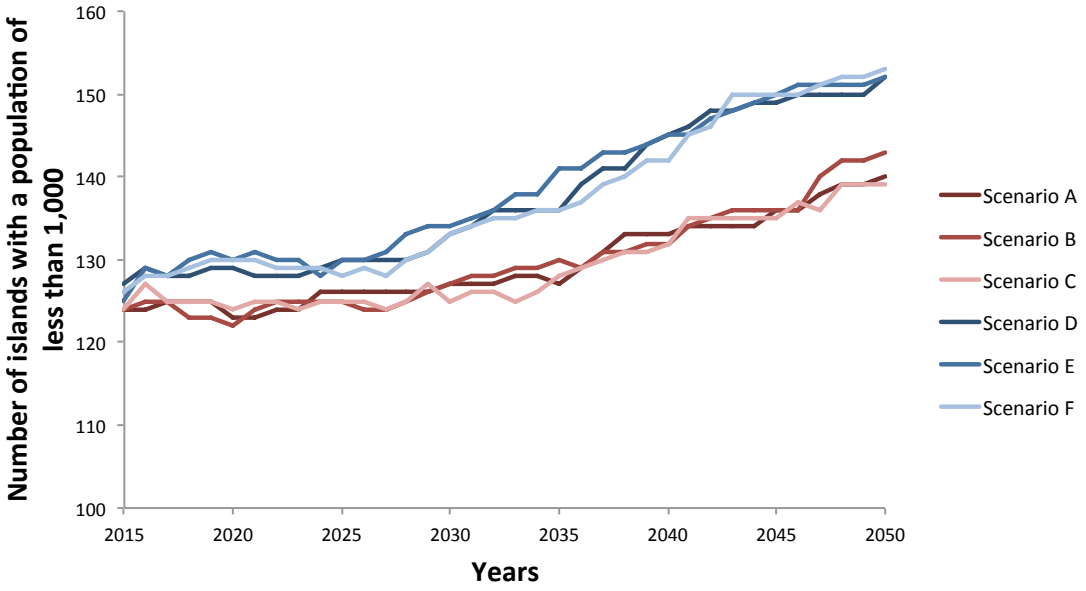

Figure 6.9 Number of islands with a population of less than 1,000 for scenario A to F.

The governance module of the ABM describes how implementation of current policy developments and plans interact with the different scenarios of population growth and environmental change. The combination of low population growth and high rates of migration results in rapidly declining populations on low populated islands. Islands with a very low population of <50 are then relocated to a higher populated island nearby. Scenario A of high global growth in a globalised world, and inclusive local social, political and economic governance results in 18 abandoned islands by 2050. Scenario E, low global growth in a globalised world, and inclusive local social, political and economic governance, results in 23 abandoned islands by 2050 (see Figure 6.10). The population policies influence migration flows between the other islands. For example, there are fewer islands experiencing high rates of out-migration in Scenario A and E as compared to the scenarios with exclusive governance.

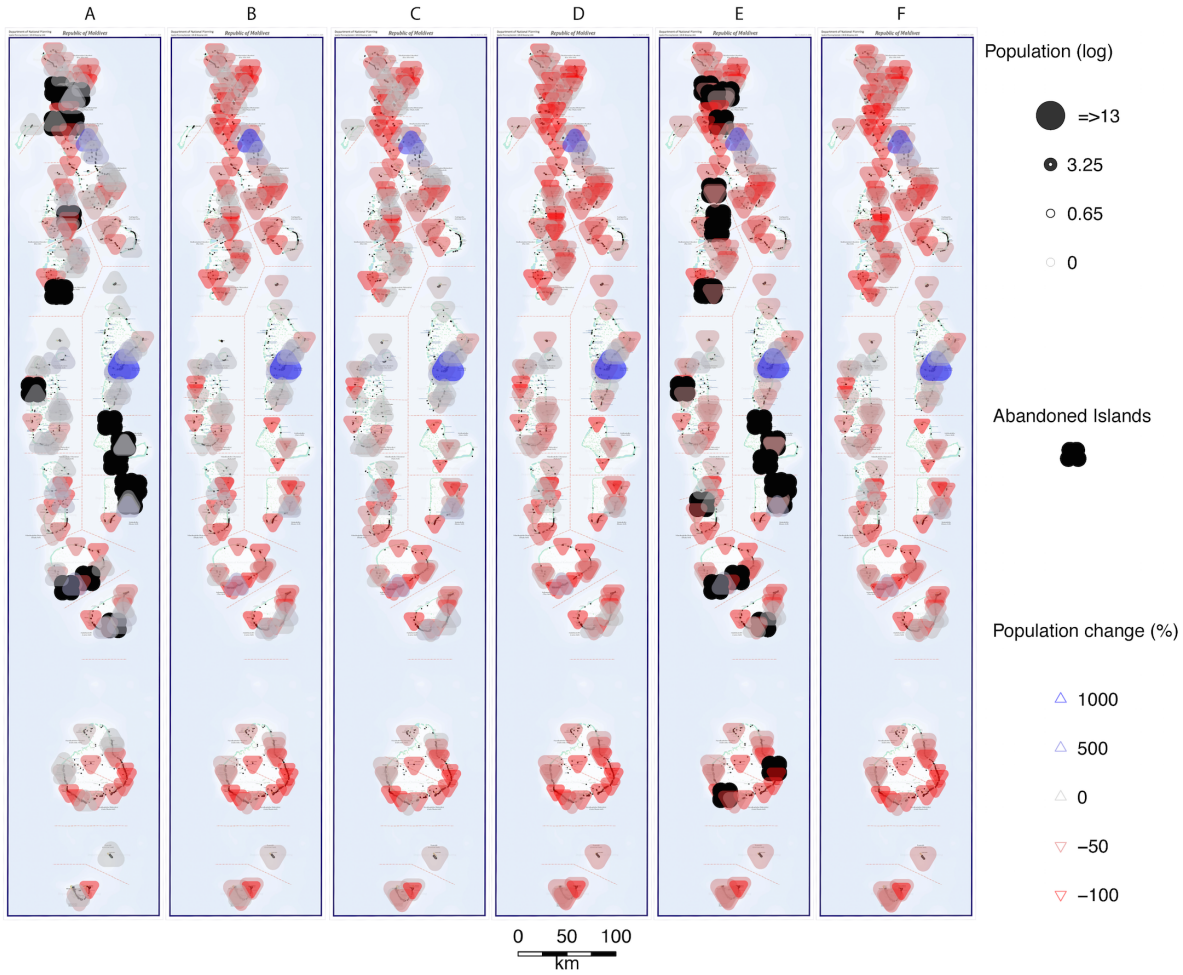

Figure 6.10 Logged population size and population change on all islands for scenarios A to F in 2050.

Scenario A, B, and E results in a total of 21,562, 23454, and 19,851 international migrants, respectively. Young, high-educated, people are most likely to move abroad. Most high-educated, young people reside in Greater Malé and therefore the impact of international migration is most pronounced in this region. Between 75-85% of international migrants have Malé or Hulhumalé as their place of origin. Hence, international migration results in (slightly) lower population in 'Greater Malé' for these scenarios (Table 6.5).

6.8 Discussion

The agent-based model simulations show how future migration flows depend on demographic, socio-economic, political, and environmental developments. The complex interaction between drivers of migration and climate change, and its interaction with individual decision-making is explained using the Conceptual Model of Migration. This theoretical framework is used as a basis to develop an agent-based model. The agent-based model is well grounded in data and is validated on the basis of historic simulations and census data. The agent-based simulations offer a

heuristic tool to explore characteristics of future migration under different development scenarios. The highest migration flows are the result of high global growth in a globalised world, inclusive local social, political and economic governance, and high impacts of climate change. The lowest migration flows are the result of future scenarios with low global growth focusing on local development, and inclusive local social, political and economic governance.

In all scenarios, Greater Malé experiences large population growth. The historic simulations underestimate the population growth in Malé and Hulhumalé and could therefore underestimate the initial population growth and the islands. However, the ABM does not include a limit on the carrying capacity of the islands and as the population in Greater Malé increases rapidly, the simulated population size in 2050 could be an overestimate. Malé is already densely populated at the time of writing and any increase in population would put further pressure on the quality of life of the people living in Malé. However, building heights on Malé increased in recent years (currently limited to 12 stories), and taller buildings (to at least 20 stories) are planned. Further, the Maldivian government is planning a range of infrastructural developments in Greater Malé. Current developments include the extension of Hulhumalé and large investments in infrastructure, commerce, tourism, and other facilities; extension of the Indira Gandhi International Airport; investments in industry on the neighbouring industrial and landfill island Thilafushi; extension and relocation of the Malé harbour to Thilafushi; and construction of a bridge connecting the airport, Hulhumalé, and Malé. This shows that infrastructure planning and provision reinforces the current trend of growing (economic) importance of the capital area, which is likely to continue for decades to come. Although there is likely a limit on the carrying capacity of the island, it is unclear when this results in a change of population and migration processes. Rather, the results show the *potential* population pressure on Malé if current trends of migration and population growth continue.

Further, the agent-based prognoses show it is unlikely that the Hulhumalé extension will provide the much-needed release of population pressure on Malé that is often stated, as internal migration pressures remain high in all future scenarios. Additionally, the future numbers of guest workers is not considered and is highly uncertain. The Hulhumalé reclamation project rather acts as an *extension* of Malé. This process is reinforced in the ABM due to the effect of social networks and increasing population size on both islands. This shows that the dichotomy between professional opportunities in Greater Malé and the low ratings of quality of life is unlikely to change, whilst the professional opportunities are likely to increase (e.g. Speelman et al., submitted-b) (see Chapter 5).

As a result of the high 'pull' factor of Greater Malé for migrants, there are increasing numbers of low populated islands in all scenarios, a process strengthened by low population growth and potential impacts of climate change and adaptation policies.

Changes in push and pull factors can influence the both the size and direction of migration flows. Such changes can occur due to developments such as tourism, large economic investments or provision of services, and due to impacts of environmental change. Examples of these developments are explored in Scenario A, B, D, and E, and result in larger internal migration flows. The sensitivity analysis of push and pull factors in Figure 6.5 further illustrates this.

These results have implications for studying migration in small islands, and areas vulnerable to environmental change in general. For example, of a hypothetical scenario of no climate change, island abandonment appears likely in the Maldives due to other drivers. In the future, environmental factors might exacerbate this process. This shows that understanding future changes in migration requires a thorough understanding of the existing socio-economic context and requires careful consideration of potential future development pathways. Agent-based modelling provides a tool for integrating environmental change and such future development pathways. The results show the *potential* of agent-based simulations to study migration flows and population distribution and are *indicative* results.

Further, the results have implications for the development of adaptations and population policies in small island settings. Adaptation and population policies such as the Safer Islands programme or the population consolidation programme need to be carefully planned and take into consideration both future environmental changes and demographic developments. For example, the ABM simulations show that destination islands of the simulated population consolidation experience high rates of out-migration. This illustrates that population and adaptation policies, such as heightening of islands or land reclamation projects, require a long-term vision on sustainability of populations on islands and that adaptation and development strategies need to consider migration dynamics. The population consolidation policy programmes, and related the 'Safer Islands' policy programme in the Maldives can only succeed in the long-term if such developments are combined with nation-wide integrative population policies and strategic objectives, as the development of Greater Malé could influence the success of these regional programmes. Using a well informed ABM grounded in a solid theoretical framework can help aid policy makers understand the interaction of their policies with different development scenarios.

6.9 Limitations to the study

The limitations to this study can be categorised in three parts.

First, the arbitrary implementations of environmental change, international migration, and policy scenarios would benefit from more specific formulation. Greater definition of the economic, social, political, and environmental change and the availability of relevant data would increase the reliability of the simulated output and would yield further insight in the interactions between the drivers of migration.

Second, foreigners who temporarily reside in the Maldives for employment purposes are not included in the analysis. According to a 2010 report on Human Trafficking by the United States Department of State, it was estimated that 110,000 foreigners, primarily of Bangladeshi descent, were working in the Maldives mainly in the construction and service sectors (U.S. Department of State, 2010). This is a significant process and its implications are not well-understood.

Third, as shown by the historic model, the size and direction of flows can be influenced due to strong developments or changes. Between 2000-2014 the ABM describes population change of the islands much better as compared to 1985-2000. This is due to strong changes in demographic patterns and a growing importance of Greater Malé and development of tourism from the late 1980s onward. Such 'thresholds of change' can change demographic processes very quickly and are not well understood, but can potentially be explored by means of agent-based modelling methods.

6.10 Conclusions

Sea-level rise and climate change are clearly a threat in low-lying islands such as the Maldives and the atoll nations in the Pacific. However, understanding the vulnerability of small islands and linking sea-level rise and climate change with migration requires a broader scope than examining impacts of sea-level rise and climate change alone. Existing socio-economic processes and future developments need to be carefully considered when assessing future demographic processes and their interaction with potential impacts of environmental change on coastal societies. Climate change is an *additional* driver in this mix and a systemic analysis is required to understand its role. The Conceptual Model of Migration and related agent-based model, grounded in prior migration research and extensive census data, show the potential of such analysis for exploring future migration and demographic developments, and interactions with socio-economic, political, *and* environmental change.

The results suggest a significant inertia in migration trends in the Maldives which makes the continued concentration of population in and around Malé almost inevitable in the coming few decades. This has profound implications for the future development of the Maldives and how they might adapt to sea-level rise and marine hazards in general. The methods outlined here

could be applied in other small island settings to better understand possible future migration behaviour. Such insight would support the broad issues of development and adaptation planning in these vulnerable settings.

Chapter 7 Conclusions and recommendations

Building on the earlier empirical analyses of historic migration behaviour and the prognosis made possible by agent-based models (ABMs) of migration, a series of conclusions and recommendations are made, including setting this work in a broader context.

7.1 Empirical analyses of recent migration in small islands: Summary of findings

This thesis analyses contemporary and potential future migration in small island settings, using the atoll nation of the Maldives as a case study. The empirical analyses in Chapter 3-5 and the agent-based model in Chapter 6 investigate the research questions presented in the introduction (Section 1.1): (1) What is known about present migration in small island settings to provide an empirical foundation for migration studies, including the potential role of climate change? (2) What are contemporary drivers and indicators of migration flows in small islands? (3) What are contemporary migration decision-making processes in small islands, including the role of the environment? (4) What are plausible future demographic and migration pathways for small islands?

This section summarises the findings related to these research questions by discussing the results on the basis of the Conceptual Model of Migration (CMM) (see Section 6.3). The CMM consists of two parts: (1) five families of drivers of migration, and (2) individual cognition. Providing a central role for the development of intention to behaviour through individual cognition using the CMM helps to better understand how the drivers of migration interact and are translated to higher scale migration flows and provides insights in potential future developments. The results described below are based on this and are grouped according to the five families of drivers as introduced by Black et al. (2011a). The five families of drivers of migration are: (1) economic, (2) social, (3) political, (4) demographic, and (5) environmental drivers. These drivers of migration are closely intertwined and should not be considered in isolation (e.g. Black et al., 2011a).

7.1.1 Economic drivers

The most mentioned factors identified in the systematic review are (perceived) employment opportunities at the potential destination of migration, or the lack of opportunities at place of residence. In addition to employment opportunities, the relative size difference of the economy at origin and destination are indicators of larger migration flows. The importance of economic drivers and employment considerations is further supported by analysis of census and other data (Section 4.6) and the importance of the *Instrumental Attitude* in Section 5.7. These results show

that (perceived) economic opportunities are an important driver of migration in the Maldives for both internal and international migration.

In the Maldives, there is a strong dichotomy in professional opportunities between the capital island Malé and its environs and other islands. Malé is the only place in the Maldives where there are significant professional opportunities, appropriate medical facilities, and educational opportunities. Therefore, together with the neighbouring Hulhumalé, it is often mentioned as the only possible island to live on or to migrate to within the Maldives. Further, present and future economic investment is focused in and around Malé. Active and near-future projects plans include the significant extension of the land area of Hulhumalé and large investments in infrastructure, commerce, tourism, and other facilities; extension of the Indira Gandhi International Airport; extension and relocation of the Malé harbour; investments in industry on the neighbouring industrial and landfill island Thilafushi; and construction of a bridge connecting the airport, Hulhumalé, and Malé. This shows that the current trend of growing (economic) importance of the capital area is likely to continue for decades to come. The importance of economic considerations for migrants, combined with continuing investments and development, are likely to result in a large further population growth in Greater Malé. The ABM simulation models presented in Section 6.7 support this view.

A further increase of population on Malé will increase pressure on its population and quality of life. Maldivians already express low satisfaction with the quality of life on Malé compared to other islands. Maldivians also already express worries about high unemployment amongst youth and lack of opportunities both in the capital and the Maldives in general. This leads to a high intention to migrate abroad for many Maldivians, an intention primarily fuelled by high expectations about employment and education opportunities at international destinations and a corresponding limit to opportunities and a low perceived quality of life in the Maldives. As yet, such considerations have not resulted in significant international migration from the Maldives. In summary, the Maldives experiences strong urbanisation, due to large differentiation in economic and education opportunities and this process is unlikely to change for decades to come. Further, there is a high potential for international migration from the Maldives, with the main generating being from Greater Malé.

The economic dimension of migration and related process of urbanisation is similar to other developing countries (e.g. DESA, 2014) and can be applied to other small island states. For example, the capital of Tuvalu, Funafuti, has a population of 6,194 in 2012 (UNFPA, 2012), 57 per cent of the total population. In Kiribati the capital city South Tarawa experiences similar strong population and development pressures as Malé, with a population of 50,182 in 2010, 52% of the

countries' population (e.g. Elrick-Barr et al., 2015). Due to the small size of these capital islands (being atolls), even relatively low population levels result in high pressure on land availability and can affect the quality of life. In Kiribati and the Maldives these pressures have resulted in land reclamation to increase the urban area for the capital (around Malé and the creation of Hulhumalé and the airport). In other small island nations, such as Vanuatu or the Seychelles, the capital islands experience similar urbanisation, but as the capital islands are larger (non-atolls) the pressure on land availability and related influence on quality of life is smaller. The capitals of these small island states all have an important economic function and attract migrants from more rural, less populated islands. However, contrary to the example of the Maldives, many other small island states have high rates of international migration and have already developed strong international migrant and remittance networks.

7.1.2 Social drivers

The systematic literature review shows that pressure from family and friends, and having connections either at places of potential destination are considered to be influential factors in small island settings (see Section 3.5.5).

In the Maldives, the high population growth of the past decades on Malé has resulted in a densely populated urban area. Malé is an island of 1.98 km^2 with a population density of 64,148 people per km^2 in 2014 (National Bureau of Statistics, 2015). By comparison, the population density of Manhattan is, at 27,673 per km^2 (U.S. Census Bureau, 2015), less than half that of Malé. As a consequence, Malé is rated low in terms of social environment, living conditions, safety, population pressure and living costs, and residents experience lower levels of happiness compared to other areas in the Maldives. The dichotomy between economic and educational opportunities, availability of health services, and quality of life results in a situation where many Maldivians say they would prefer to live on other islands if there would be adequate opportunities. Further, Maldivians, especially in Malé, expect quality of life to be better abroad which helps to explain their high intentions to migrate internationally. Maldivians expect that the creation and development of Hulhumalé will help decrease the population pressure on Malé. However, between 2006 and 2014 population greatly increased in Hulhumalé, Vilimalé, *and* Malé. This is further supported by the findings in Section 6.7, where the population of both Hulhumalé *and* Malé increases. This shows that the Hulhumalé reclamation project acts as an *extension* of Malé rather than an alternative migration location. This shows that the dichotomy between professional opportunities in Greater Malé and the low ratings of quality of life is unlikely to change, whilst the differentiation between economic and education opportunities is likely to increase.

The influence of population pressure on quality of life, and related migration intentions, depends on both levels of development and the geography of the capital area. As mentioned in section 7.1.1, Funafuti in Tuvalu and South Tarawa in Kiribati experience similar population pressure developments and deterioration of quality of life in the capital area as compared to Malé. In other small island nations, such as Vanuatu or the Seychelles, the capital islands experience similar urbanisation. However, as the capital islands are larger (non-atolls) there is less pressure on land availability and related quality of life.

Unlike other small island states, the Maldives has not yet experienced high rates of international migration and there are no extensive international migration networks. Such migrant networks ensure that potential migrants already have a cultural bond with the place of destination, often already have friends and family living at the place of destination, and have developed potential professional connections. Investments, (lack of) international migrant networks, policies, and other barriers limit the translation from intention to actual behaviour. These barriers are higher in the Maldives in comparison to small island nations in the Pacific. The Pacific island nations have strong cultural and historic connections with Australia and New Zealand and large migrant networks. The development of such migrant networks for the Maldives would almost certainly increase international migration flows in the near future, and international migration may be a reinforcing process. Hence, an increase in international migration from the Maldives would make it more like other atoll nations. In contrast, the large number of guest workers makes the Maldives distinct from other island nations.

7.1.3 Political drivers

The systematic review identifies important political and policy processes for small island nations (see section 3.5.6). These results have been confirmed in the other chapters.

First of all, the political and cultural relations between New Zealand and Australia and small island states in the Pacific are particularly close. The *Māori* culture in New Zealand is closely related to the Polynesian culture in the Pacific (Shen and Binns, 2012). Similar relations exist between Spain and the Canary Islands (Alemán and León, 2010). In addition to the established migrant networks and (perceived) professional opportunities, the relations between these nations result in more lenient immigration policies in destination countries, increasing migration.

Second, although the exact effects on migration are uncertain, political trouble and turmoil will most certainly influence migration behaviour.

Third, a political issue specific for small island states consisting of a large number of islands, such as Tuvalu (several), Tonga (hundreds), and the Maldives (thousands) is the dispersion of population over the islands. Whereas a large fraction of the population is living in or around the capital islands, the remainder is spread out over a large number of islands. This requires large investments in development to provide adequate services and resources to the entire national population. For example, the government of the Maldives argues that it costs up to four times the investment as compared to other developing countries to develop the required infrastructure (Ministry of Planning and National Development, 2004). Hence, it is economically unsustainable to provide adequate services and resources to the dispersed population of over 200 populated islands. It is more cost-effective to develop a limited number of key islands and the Maldives are following this path with the population consolidation and 'Safer Islands' policy programmes. These, often unpopular (e.g. Kothari, 2014), population consolidation policies lead to an increase in abandonment of islands. These plans are reinforced by the threat of environmental change due to climate change, as the government argues it would be unsustainable to provide adequate protection on all currently inhabited islands.

7.1.4 Demographic drivers

Demographic drivers include population dynamics such as birth and mortality rates, life expectancy, literacy, and population size and density. Birth and mortality rates are directly linked to population size and hence the size of migration flows. They also influence migration decisions indirectly, through, for example, increased population pressure or, if the population is decreasing, through population policies as described above. The agent-based model prognoses presented in Section 6.7 support this.

In addition to changes in the existing population, international in-migration can be an important demographic driver. Guest workers are an increasingly important factor in the Maldives. The guest workers of mainly Bangladeshi descent mainly work in construction and tourism. The 2014 Census is the first attempt to assess their numbers, with an estimate of 58,683 people. However, an earlier estimate for 2010 was 110,000 people (U.S. Department of State, 2010) and it may take time to develop robust and agreed estimates. Certainly the numbers appear to be growing. Guest workers are a specific demographic characteristic of the Maldives compared to the other small island states, which mainly experience out-migration. This is due to the relatively well-developed economy of the Maldives as compared to other small island states.

7.1.5 Environmental drivers

Climate change and small islands are widely discussed in the media with resulting environmental change as the key driver. Contrary to widespread expectations in the media, political discussions, and in some academic reports, this research shows that environmental factors do not currently play a role in considerations about internal or international migration for Maldivians. People mentioned that other factors are more important in their considerations and that sea-level rise and climate change, as well as protection from storms, and levels of erosion do not play a role. This finding is in line with a study of Mortreux and Barnett (2011), who found that climate change is, as yet, not of importance for migration decisions in Tuvalu. Maldivians are, as yet, unlikely to migrate *in anticipation of* climate change.

However, Maldivians are worried about future impacts of climate change and often state that in the future sea-level rise might become a factor. Current intentions to migrate are subject to change and it is difficult to predict how perceptions and attitudes to migrate may alter in the future. Environmental considerations could become more important when faced with more rapid change, extreme climatic events such as storms or big swells, or other adverse events such as tsunamis. Further, climate change could influence migration through *indirect* processes. For example, if climate change affects employment opportunities or quality of life this could lead to an increase in migration, while in addition to direct effects, adverse extreme events could undermine confidence.

There is a risk and even likelihood that in the discourse about impacts of climate change on small island nations that any migrants from small island nations will be classed as 'climate refugees', especially if there is a future increase of migration flows. It is however, important to consider that such flows are not influenced by climate change alone, but that decisions of individuals are rather embedded in existing attitudes and values toward international migration. Lowering barriers to migration by, for example, means of policies in anticipation of climate impacts could lead to an increase in international migration. Such migration flows would not necessarily be caused by direct physical impacts of climate change and sea-level rise, but would rather be a manifestation of existing migration intentions and lowering barriers to migration. This finding is supported by Mortreux and Barnett (2009) in Tuvalu.

7.2 Implications of findings

This thesis analyses contemporary and potential future migration in small island settings, using the atoll nation of the Maldives as a case study. The main motivation to study migration in such is the high vulnerability to climate change and related sea-level rise of small islands. Due to the high

vulnerability to such changes, the small island states have been linked to an increase in migration and island abandonment. However, prior to this study, migration in small island states has not been studied extensively. Contrary to views often portrayed in media, politics, and academic reports linking migration and island abandonment in small island settings, the results describe complex processes, where migration and island abandonment are linked to a range of different intertwining drivers and individual decision-making processes. This result has important implications for studies linking migration to climate change, and implications for adaptation and population policies in small island settings in particular.

7.2.1 Migration and the environment

In this study, people were found to mainly move for professional purposes, general quality of life and well-being, and family. There is no effect of observed climate change on migration to date, reflecting that observed climate change has been modest compared to expectations for the 21st Century (cf. Nicholls et al., 2009). In addition, migration *in anticipation of* climate change is not apparent from the data collected either, and seems unlikely unless conditions change significantly.

This has implications for studying migration in small islands, and areas vulnerable to environmental change in general. Firstly, migration will likely be occurring today due to multiple non-environmental factors. Hence, rather than looking at direct impacts of environmental change on migration considerations, understanding its interaction with these other drivers of migration *and* how these individual drivers of migration will develop in the future is essential. This requires a thorough understanding of the existing socio-economic context and requires careful consideration of potential future development pathways. For example, under a hypothetical scenario of no climate change, island abandonment appears likely to occur in the Maldives due to the existing non-environmental drivers of migration. In the future, environmental factors might exacerbate this process.

This shows that it is important to consider all drivers of migration *and* individual decision-making when looking at future demographic and migration developments. The Conceptual Model of Migration provides a useful framework for analysing migration and its drivers, including its environmental component.

The effect of environmental change on migration will depend on the physical component of environmental change and the development and response of societies. The responses in terms of population movement will be non-uniform, depending on the socio-economic setting of each specific society and its future developments, and very difficult if not impossible to predict in a

deterministic sense. In contrast, the drivers and their interactions can be diagnosed and interpreted, as presented here.

7.2.2 Implications for policy makers

Islands are usually considered as canaries in the coal mine in the climate change debate and it is widely assumed that adaptation is not possible or hopeless. Further, in the debates of climate change and migration, migration and displacement are often solely perceived as a problem. However, the development of Hulhumalé and the 'Safer Islands' programme demonstrates the capacity of small island nations to adapt to climate change. Land reclamation projects and the raising of islands are viable adaptation options for the short- to medium term and can certainly 'buy time' for the small island nations. Taking approaches applied in other coastal contexts, such as the management of flooding in London, and recognising adaptation as a series of steps down a pathway, may provide a long-term strategy (see Ranger et al., 2013). This shows there are opportunities for adaptation and development in small island nations. Such adaptation and development strategies need to consider migration dynamics.

The population consolidation policy programmes, and related Safer Islands policy programme in the Maldives can only succeed in the long-term if such developments are combined with wider policy and strategic objectives, such as population pressure and quality of life. For example, it is unlikely that the Hulhumalé extension will provide the much-needed release of population pressure on Malé, as internal migration pressures remain high and the future numbers of guest workers is uncertain (and anecdotally growing rapidly). The Hulhumalé reclamation project rather acts as an *extension* of Malé. The *pull* factor of Greater Malé only increases due to the concentration of investment. This development could potentially clash with local population consolidation programmes and the 'Safer Islands' policy, which focus on developing regional centres. Further, population policies force people to leave their home island and these population consolidation programmes are unpopular (e.g. Kothari, 2014). There is a risk that such policies and forced relocations destroy the fabric of island life. However, such regional developments is one key way to reduce population pressure in Greater Malé and to achieve sustainable development of peripheral islands. Such regional programmes can only succeed if they provide an alternative to Greater Malé, and are combined with employment and education opportunities, as well as developed in terms of quality of life, healthcare, and social environment.

Successful population policies and adaptation investments in the Maldives and other small island nations need to consider migration dynamics, employment, education, and other services, and requires an integrative and nation-wide view of development and adaptation.

7.3 Recommendations for further work

The analysis presented in this thesis support the theory that people are unlikely to move in *anticipation* of climate change, but rather base their decision on their current situation, what means that presently socio-economic drivers dominate. To understand if this is context specific, or only applicable to certain regions, further research looking at changes in future migration should carefully consider environmental change *and* its potential future socio-economic developments. This research presented an improved method of analysis and theoretical frameworks to help provide such context and helps to embed future analyses of environment and migration in a broader scope of migration processes and decision-making.

These methods can be applied in different regions. For example, the Conceptual Model of Migration could be applied to analyse migration in other small island settings, such as Tuvalu or Kiribati. Building on historic analyses such as Arenstam Gibbons and Nicholls (2006) in the Chesapeake Bay, USA it could also be applied to islands in developed countries where good datasets are available. Smith island and Tangier island in the Chesapeake Bay are examples of potential future study areas where adaptation due to sea-level rise is essential. Further, it would be interesting to apply the framework and methods to other vulnerable areas where migration is important and there are potential changing migration patterns, including non-island settings. The exact processes are context dependent, and a comparison between different regions vulnerable to climate change using this framework could yield insights both about differences between regions and general migration processes, including its links with the environment, and further test the strength of the theoretical framework and methods.

There are however, also issues that remain to be addressed within the scope of migration and environmental change in small island nations. The effect of population policies and potential adaptation option on migration flows and intentions need to be better understood to develop good development policies. Investigating the migration decision-making on the level of households could yield further insights. Further, expats play a significant role in the Maldives, and its role within society and relation to migration is not well understood. Lastly, many of the small island states are unstable politically and heavily dependent on foreign aid or income. Its effects on migration are not well understood.

Further, in addition to understanding migration behaviour and patterns, it would be beneficial to focus on the potential impact of existing and changing migration patterns in small islands. The internal migration flows in the Maldives greatly affect Maldivian society. The dichotomy between the urban area and rural islands in the Maldives is expanding and puts forward questions about Maldivian identity. The traditional quiet island life clashes with urban development and

investments around Malé. The unpopular population consolidation policies could put further strain on its society and its potential impacts are not well understood. In terms of adaptation and population policies, such effects also need to be better understood.

Lastly, impacts of environmental change influence the different drivers of migration. If individuals do not move in anticipation of potential impacts, impacts of climate change that affect daily livelihoods or quality of life indirectly affect migration behaviour. For example, changing patterns in rainfall could influence agricultural income and as an effect influence attitudes to migration. Further disentangling such effects could be achieved by carefully assessing the different considerations of individuals to migration and testing how these considerations might be influenced by climate change. Such effects can potentially be explored using methods presented in this thesis. For example, conducting surveys using Likert-scales to rate a person's income and specifically asking questions how a change in income would influence their attitudes to migration would provide interesting insights in the relation between income and migration behaviour. Estimates of a change in income due to climate change can as such be linked to changes in migration flows using, for example, agent-based modelling methods.

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Appendix A

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Appendix B Survey

Greetings, I am Laurens Speelman, a researcher from The Netherlands and currently conducting a research in the Maldives.

Your contribution to my research is very much appreciated. The interview will take approximately 15 minutes. Your participation is voluntary. Would you be willing to take part in this questionnaire?

1) No. Thank you for your time.
2) Yes. Proceed with the questionnaire.

Before we start I would like to assure you that all the information you share will not be shared with anyone else. The answers you give I will fill out on paper, but your name will not be on the questionnaire, so all answers will be completely confidential. Also, for the usefulness of the interview it is very important to know that you can be completely open. Please know that for me it doesn't matter which answers you give and that different people give different answers and that is okay. There is no right and wrong in this interview. I am only interested in your views, beliefs, opinion, and how you do things.

Do you have any questions so far?

If you have any questions or if anything is unclear during the interview please feel free to ask questions and I will try to explain. You may refuse to answer any questions during the survey.

Questionnaire number…….

Date…….

Atoll and island code:……

A. Personal Background

Code	Question	Answer
BF1	What is your date of birth?	Year
BF2	What is your place of birth?	Name/island code
BF3	What is your sex?	1: Male 2: Female
BF4	What is your nationality?	1. Maldivian 2. Other
BF5	Are you married?	1. Yes 2. No
BF6	Does your spouse live on this island?	1. Yes 2. No
BF7	Do you have children?	1. Yes 2. No
BF8	How many children do you have?	Number
BF9	How old are your children?	List of ages
BF10	What is the size of the household?	Number
BF11	What is your relationship to the head of household?	1. Head of household 2. Spouse 3. (Step) child 4. Other relative 5. Other

BF12	What is your highest attained education?	Current grade system in the Maldives (1-12): 7. Grade 7 13. O-level 14. A-level 15. Diploma 16. First degree 17. Masters degree 18. PhD
BF13	During last week were you engaged in any income generating activity for more than 1 hour?	1. Yes 2. No
BF14	What is the economic activity in which you spent most of the time during last week?	1. Tourism 2. Fishing 3. Farming 4. Industry 5. Government 6. Education 7. Construction 8. Other (specify)
BF15	Do you own land, a house, or business?	1. Yes 2. No
BF16	What was your income in the last month?	MVR:

B Residence and migration behavior

Code	Question		Answer
BEH1	Do you live on this island?		1. Yes 2. No
BEH2	How long have you lived on this island?		Number
BEH3	What is your history of migration?		Fill out below
	Year	**Island of origin**	**Island of destination**

C Determinants – Characteristics of your home island

In the following part of the survey I am going to ask you questions about your opinion about the place where you are currently living. Please keep in mind that there is no right or wrong. I am only interested in your attitude and opinions. The questions I will ask are short and specific. Some are not questions, but statements. If you have a question about the exact meaning of any of the questions or statements, please feel free to ask.

Code	**Question/statement**	**1 Very dis-satisfied**	**2 Dis-satisfied**	**3 Neutral**	**4 Satisfied**	**5 Very satis-fied**
SQ1	How satisfied are you with your income?					
SQ2	How satisfied are you with your job?					
SQ3	How satisfied are you with your current living conditions?					
SQ4	How satisfied are you with your social environment?					
SQ5	How satisfied are you with clean water provision and food quality on this island?					
SQ6	How satisfied are you with the mentality of the people on this island?					
Code	**Question/statement**	**1 Very low**	**2 Below average**	**3 Average**	**4 Above average**	**5 Very high**
SQ7	How do you rate the health care provision on this island?					
SQ8	How do you rate the educational possibilities on this island?					
SQ9	How do you rate the amount of nature and space on this island?					
SQ10	How do you rate the level of quietness and peace on this island?					
SQ11	How do you rate the					

	level of pollution on this island?					
SQ12	How do you rate the level of population density on this island?					
SQ13	How do you rate crime levels on this island?					
SQ14	How do you rate the level of protection to storms on this island?					
SQ15	How do you rate the level of environmental degradation/erosion on this island?					
SQ16	How do you rate your overall level of happiness?					
Code	**Question/statement**	**1 Not at all**	**2 Slightly**	**3 Moderately**	**4 Very**	**5 Extremely**
SQ17	How much do you think climate change will impact this island?					
SQ18	Do the effects of sea-level rise affect your daily life?					
SQ19	Do you think sea-level rise will affect your daily life in the future?					
SQ20	Do the effects of climate change affect your daily life?					
SQ21	Do you think climate change will affect your daily life in the future?					
SQ22	Environmental degradation/erosion is a problem					
SQ23	Environmental problems in the place I live now make life hard for me					
SQ24	Does the threat of storms or other extreme events worry you?					

D Determinants – Internal migration

In the following part of the survey I am going to ask you questions about your opinion and expectations about migration within the Maldives (e.g. moving between islands in the Maldives). Please keep in mind that there is no right or wrong. I am only interested in your attitude and opinions. The questions I will ask are short and specific. Some are not questions, but statements. If you have a question about the exact meaning of any of the questions or statements, please feel free to ask.

Code	Question	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
INT1	Do you intent to migrate?					
INT2	I would like to migrate to another island					
INT3	I will migrate in the coming two years					
INT4	Where would you migrate if you would move away from this island?	Island name/code:				
AAL5	Do you expect to become happier if you migrate?					
AAL6	Do you think your quality of life will improve if you migrate to another island?					
AAL7	Would you expect to live in a pleasant living environment?					
AAL8	Would you expect to live in a pleasant socially amenable community?					
AAL9	Do you expect the mentality of the people to be more pleasant if you migrate?					
IAL10	I have good connections for employment if I migrate					
IAL11	Maybe I will leave because of environmental problems here					
IAL12	The environment					

	influences my considerations about migration					
IAL13	I expect my income to increase if I migrate					
IAL14	Do you have good job prospectives if you migrate?					
IAL15	Do you expect health care facilities to be better if you migrate?					
IAL16	If I migrate I will have better educational opportunities					
IAL17	Nature and space are a factor when thinking about migration					
IAL18	Quietness and peace are a factor when thinking about migration					
IAL19	Does the level of pollution play a role when thinking about migration?					
IAL20	Does the level of population density play a role when thinking about migration?					
IAL21	Crime levels play a role when thinking about migration					
IAL22	Do you think clean water provision and food quality will be better if you migrate?					
IAL23	Do the threat of storms or other extreme events play a role?					
IAL24	Do protection measures to storms and other extreme events play a role?					
IAL25	Do potential impacts of climate change play a role?					
IAL26	Do levels of erosion play a role?					
IAL27	Do potential impacts of sea-level rise play a role?					
OAFL28	Policies enable me to					

	migrate to another island					
PBCL29	I know that I am capable of migration					
PBCL30	I have the economic means to move					
SNL31	My friends and family want me to stay					
SNL32	Do considerations about the future of your family (children) play a role?					
SNL33	If I move that must be for the benefit of my family					
PBCL34	If I want to I can migrate to another island in the next year					
SNL35	I have friends or family who migrated to other islands	1. Yes			2. No	

E Determinants – <u>International migration</u>

In the following part of the survey I am going to ask you questions about your opinion and expectations about <u>international migration</u> (e.g. <u>leaving the Maldives</u>). Please keep in mind that there is no right or wrong. I am only interested in your attitude and opinions. The questions I will ask are short and specific. Some are not questions, but statements. If you have a question about the exact meaning of any of the questions or statements, please feel free to ask.

Code	**Question**	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
INTIN1	Do you intent to migrate?					
INTIN2	I would like to migrate to another country					
INTIN3	I will migrate in the coming two years					
INTIN4	Where would you migrate if you would move away from the Maldives?	Country:				
AAINT5	Do you expect to become happier if you migrate?					

AAINT6	Do you think your quality of life will improve if you migrate to another country?					
AAINT7	Would you expect to live in a pleasant living environment?					
AAINT8	Would you expect to live in a pleasant socially amenable community?					
AAINT9	Do you expect the mentality of the people to be more pleasant if you migrate?					
IAINT10	I have good connections for employment if I migrate					
IAINT11	Maybe I will leave because of environmental problems here					
IAINT12	The environment influences my considerations about migration					
IAINT13	I expect my income to increase if I migrate					
IAINT14	Do you have good job prospectives if you migrate?					
IAINT15	Do you expect health care facilities to be better if you migrate?					
IAINT16	If I migrate I will have better educational opportunities					
IAINT17	Nature and space are a factor when thinking about migration					
IAINT18	Quietness and peace are a factor when thinking about migration					
IAINT19	Does the level of					

	pollution play a role when thinking about migration?					
IAINT20	Does the level of population density play a role when thinking about migration?					
IAINT21	Crime levels play a role when thinking about migration					
IAINT22	Do you think clean water provision and food quality will be better if you migrate?					
IAINT23	Does the threat of storms or other extreme events play a role?					
IAINT24	Do protection measures to storms play a role?					
IAINT25	Do potential impacts of climate change play a role?					
IAINT26	Do levels of erosion play a role?					
OAFINT27	Do potential impacts of sea-level rise play a role?					
PBCINT28	Policies enable me to migrate to another country					
PBCINT29	I know that I am capable of migration					
SNINT30	I have the economic means to move					
SNINT31	My friends and family want me to stay					
SNINT32	Do considerations about the future of your family (children) play a role?					
SNINT33	If I move that must be for the benefit of my family					
PBCINT34	If I want to I can migrate to another country in the next					

	year					
SNLINT35	I have friends or family who migrated to other countries	1. Yes			2. No	

E – Closing questions

Lastly, I would like to ask you a few short questions about the questionnaire.

1. Do you have any comments or additional information you would like to share?

2. Did I miss any important aspects related to migration?

3. Do you have any additional comments about the relation of environment and environmental change to migration?

4. Do you expect climate change to play a role in future considerations about migration?

5. If so, what factors we talked about today do you think would be influenced?

Thank you for your time and your contribution to this research.