Loss & Damage

Loss and damage from coastal erosion in Kosrae, The Federated States of Micronesia

Iris Monnereau and Simpson Abraham

November 2013

CDKN
GERMANWATCH
ICCCAD International Centre for Climate Change and Development
MCII
UNITED NATIONS UNIVERSITY
UNU-EHS

Author affiliation:

- Dr. Iris Monnereau: Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies, Barbados
- Simpson Abraham: Federated States of Micronesia's Pacific Adaptation to Climate Change Project (FSM-PACC)

This report should be cited as:

Monnereau, I. and Abraham, S. (2013). *Loss and damage from coastal erosion in Kosrae, The Federated States of Micronesia*. Loss and Damage in Vulnerable Countries Initiative, case study report. Bonn: United Nations University Institute for Environment and Human Security.

Layout: Miquel Colom

Table of Content

Acknowledgements

We would like to thank the United Nations University Institute for Environment and Human Security (UNU-EHS) in Bonn, Germany – in particular, Dr Koko Warner and Dr Kees van der Geest. This study would not have been possible without the financial support of the Climate and Development Knowledge Network, UK.

In addition we would like to thank the Federated States of Micronesia Pacific Adaptation to Climate Change (PACC) project for providing us and the enumerators with a workplace during our fieldwork. We are especially indebted to the enumerators who conducted all the surveys: Dorline Nithan, John Reynold, Kinere Kinere, Samuel Palik, Kaiulani Siba, Curt Benjamin, Rossey Sigrah, Austin Albert, Osamu Telenna and Elsina Edmund. Carlos Cianchini has also been of great value to the project, as he helped to provide the practical support needed to carry out the focus group discussions. Ginny Jose deserves special thanks for his immeasurable help – providing practical support for both focus group discussions and in-depth interviews, and coordinating and carrying out the surveys and data entry. Also special thanks to Lisa Abraham, college intern student working at the PACC offices, who helped with the data input. We would also like to express our greatest gratitude to all of the respondents and interviewees, as well as those who participated in the focus group discussions, for their time and effort in sharing their thoughts, experiences and concerns with us. This report benefited greatly from feedback provided by Professor John Connel and Doug Ramsey.

Executive summary

Introduction

Small Island Developing States (SIDS) are expected to be disproportionately affected by climate change, sea-level rise and extreme weather events, due to their social, economic and geographical characteristics – for example, their limited size, proneness to natural hazards, low-lying areas and low adaptive capacity (Mimura et al., 2007). They are particularly vulnerable to sea-level rise, which is expected to increase in the near future and exacerbate coastal erosion, inundation, storm surges and other coastal hazards (Mimura et al., 2007). In SIDS, the projected sea-level rise of 5mm per year for the next 100 years would cause: increased coastal erosion, loss of land and property, dislocation of people, increased risk from storm surges, reduced resilience of coastal ecosystems, saltwater intrusion into freshwater resources, and high resource costs for adaptation (Mirza, 2003). Coastal erosion is one of the expected consequences of climate change, particularly in the Pacific Ocean. Kosrae, one of the four states of the Federated States of Micronesia (FSM), has experienced severe coastal erosion over the past decades as a result of El Niño/La Niña Southern Oscillation (ENSO), sea-level rise and human activity. This is expected to increase as climate change impacts become more significant in the near future.

Small Island Development States are particularly vulnerable to sea-level rise

The research

The four main villages on Kosrae are all at significant risk from coastal erosion, as 70% of all households are located below or seaward of the 4m contour above sea level (NIWA, 2013). Coastal erosion, both gradual and that occurring as a result of high (king) tides, has already affected housing conditions on Kosrae. This is expected to worsen, as sea levels will continue to rise and extreme weather events are expected to become more frequent. Although many residents have adopted adaptation measures to deal with coastal erosion, these measures have, in most cases, not been enough to offset adverse impacts. Adaptation measures have their limitations and can also have negative consequences.

Coastal erosion already has severe impacts on Kosrae and is expected to worsen

Loss and damage refers to the negative effects of extreme weather events and slow-onset climatic changes that people have not been able to cope with or adapt to

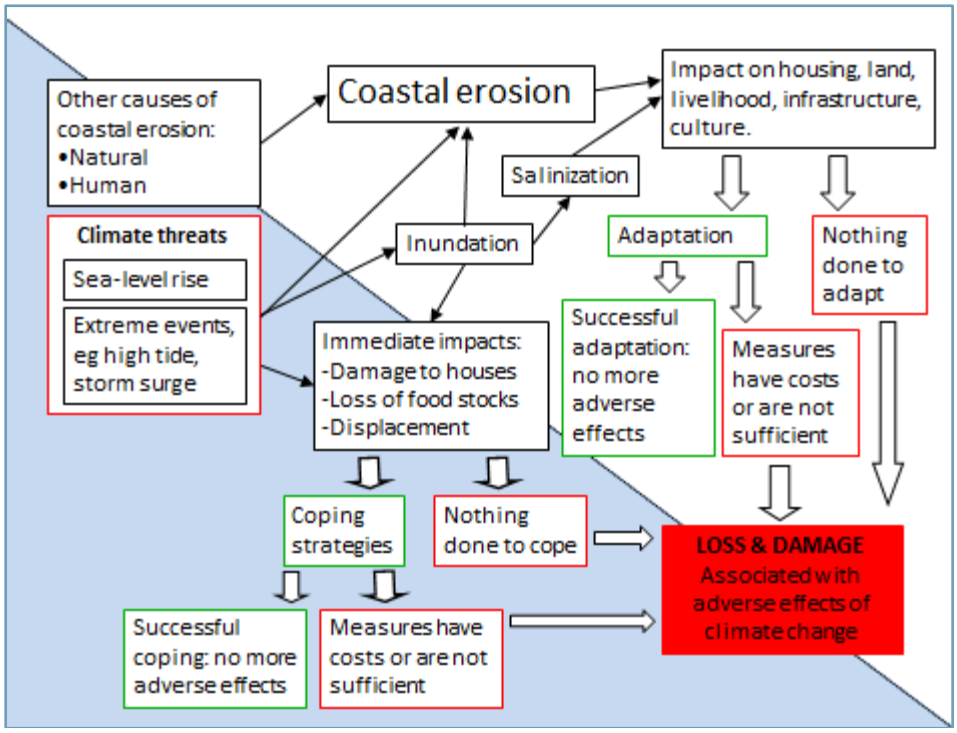


Figure 1: Framework of loss and damage project on Kosrae, Micronesia.

Note: The background colours divide the part of the study that looked at coping with extreme events (blue) and adaptation to slow-onset changes (white)

This research looks at loss and damage from climate change. 'Loss and damage' is defined here as the negative effects of extreme weather events and slow-onset climatic changes that people have not been able to cope with or adapt to. This case study focuses on the extent to which communities have been affected by sea-level rise and more extreme climate events, through coastal erosion and other impacts, the adaptation and coping strategies households have carried out, their limitations, and the loss and damage to housing on Kosrae. For this research, we administered 363 questionnaires, conducted six focus group discussions and 12 in-depth interviews during July 2012.

Figure 1 shows the framework of this study. Coastal erosion in this study is considered to be impacted by climate change variables such as sea-level rise and extreme weather events, as well as other factors such as human activity (eg reef dredging and sand mining) and natural causes (eg ENSO patterns). In this study we focus on the direct impacts of coastal erosion on housing and indirect impacts through inundation and salinization. Coastal erosion negatively affects residents through structural damage and loss to livelihoods, land, infrastructure, houses and culture.

87% of the surveyed households experienced adverse effects of coastal erosion and 51% adopted adaptation measures

Results

Slow onset changes: The majority of survey respondents (87%) on Kosrae have experienced adverse effects of coastal erosion over the past 20 years. The coastline has retreated, beaches have

disappeared, and people have suffered loss and damage to land, houses and livelihoods. Of those who experienced adverse effects of coastal erosion, 80% said this had directly affected their household economy, mostly as a result of loss and damage to crops, economic trees and housing. Of those who experienced negative impacts on their household economy, 53% reported damage to their house. The shoreline is often right alongside the house rather than ten metres away, as it was 15 years ago. Of those who said they suffered from coastal erosion, 51% said they carried out adaptation measures. The most popular measures were:

- building seawalls (29%)
- landfilling (29%)
- planting trees along the coastline (15%)
- elevating houses (11%).

For 92% of the adapting households, the measures were not enough to avoid negative effects of coastal erosion

However, 92% of those who had carried out adaptation measures said these measures were not enough to combat coastal erosion and its impacts. Respondents who did not carry out any adaptation measures indicated that this was mostly due to lack of financial means (71%), lack of know-how (41%) or skills (40%), or lack of other resources (18%). Only 3% of respondents who suffered from coastal erosion said they did not carry out any adaptation measures because it was not considered a priority; this very low percentage emphasises the fact that coastal erosion is perceived to be a very serious threat by many people on the island.

Extreme weather events: Of the households surveyed, 57% have also suffered the adverse effects of extreme weather events, specifically high (king) tides. These events have had short-term (eg damage to housing) and long-term impacts (eg salinisation of agricultural land and economic trees) on households. The loss of land and protective plants and trees along the shoreline further intensifies the problems. Of those who experienced these extreme events, only 25% said they carried out coping mechanisms, yet 96% felt the measures were insufficient. Measures undertaken were mainly building or repairing of temporary seawalls, repairing houses, with long-term coping strategies being adopted in a minority of cases.

Conclusion

Coastal erosion has severely impacted the livelihoods, housing and culture of the residents of Kosrae. Coastal erosion on the island has been caused by ongoing climate changes as well as other natural factors and human activity over the past 50 years. Dredging of the reef flat, sand

Coastal erorsion results from a combination of climatic stressors and human activities

mining, cutting trees and mangroves, and altering river outlets have all had a profound impact on

current coastal retreat. At the same time, climate change impacts such as sea-level rise and climate variability impacts such as ENSO events have exacerbated coastal vulnerability on the island. It has become clear that sea-level rise is greater in the FSM area in comparison to surrounding areas in the Pacific Ocean, and residents indicate that the extreme weather events of the past few years have been the worst they have seen in the last 20 years. Increasing coastal erosion will reinforce this cycle – that is, the more trees lost to coastal erosion, mangroves and the protective reef, the greater the impact of coastal erosion. This study has shown that despite their adaptation and coping measures, Kosraen households still suffer from loss and damage. Coastal erosion has a significant impact on their livelihoods, housing and culture. Some loss and damage can be repaired (eg to housing or infrastructure), while some, such as loss of income or culture, is much more difficult to restore.

This study has shown that despite their adaptation and coping measures, Kosraen households still suffer from loss and damage.

In order to improve future adaptation, collective collaboration and planned measures are necessary. Policy recommendations include:

- moving households to uphill areas;
- replanting of eroded coastal areas;
- protection of mangroves;
- maintaining coastal defences already in place;
- support infrastructure along inner roads and other infrastructure;
- support the elevation of houses.

Chapter 1: Introduction

"The storm came and broke the door and smashed the windows. The shoreline behind our house had already completely disappeared because of coastal erosion, so now the seawater quickly filled the house. Everything inside the house got wet – mattresses, clothes and furniture. The kitchen next to the house, built of bamboo and thatch, completely washed away. The only thing left was the cement floor. Our three dogs were washed away and disappeared in the dark. Water also entered the pigpen, but fortunately, the pigs survived. We had to stay with family for ten months while we rebuilt our home. We are building a new house in the hills, however, because the seawall and gabions we have built ourselves are no longer protecting us. The gabion nets are rusting and the waves are breaking down the seawall. The sea is almost reaching our house. Our grandson will not be able to grow old in this house." (Alokoa Jonithan, 55 years old, male, Tafunsak, Kosrae, Federated States of Micronesia)

Alokoa Jonithan's experience with the impacts of a storm on his housing and livelihood as a result of already pressing challenges of coastal erosion on Kosrae, Federated States of Micronesia (FSM), illustrates the impacts of climate change stressors on those living on small vulnerable islands. Small Island Developing States (SIDS) are already, and will continue to be, disproportionately affected by climate change, sea-level rise and extreme weather events (Mimura et al., 2007). This is due to their social, economic and geographical characteristics – such as their limited size, insular geography and remoteness, proneness to natural hazards, low-lying areas, and low adaptive capacity (Mimura et al., 2007; Nurse et al., 2001; Pelling and Uitto, 2001; Kelman, 2010; Douglas, 2006). SIDS are a grouping of 52 tropical island states, including FSM, that have been banded together under the United Nations to address common sustainability challenges (Mercer et al., 2012). Although SIDS produce only 0.6% [1] of global greenhouse gases, they will need to reallocate scarce resources away from economic development and poverty alleviation in order to adapt to the growing threats posed by global warming (Nurse and Moore, 2005).

SIDS produce only 0.6% of global greenhouse gases, but they need to use scarce resources to adapt to the growing threats posed by global warming

SIDS are particularly vulnerable to sea-level rise, which is expected to increase in the near future and exacerbate coastal erosion, inundation, storm surges and other coastal hazards (Mimura et al., 2007). Coastal erosion is considered to be one of the most serious climate change concerns for Pacific Ocean islands (Mimura, 1999; Mimura et

[1] This percentage is based on our calculations of SIDS' carbon production in 2009 from the Carbon Dioxide Information Analysis Center. See http://cdiac.ornl.gov/trends/emis/meth_reg.html (accessed July 23rd 2013). All SIDS are included in this analysis except for: American Samoa; Guam; Puerto Rico; Tuvalu; and the US Virgin Islands.

al., 2007; Fletcher and Richmond, 2010). Over the past few decades, FSM has experienced increasing coastal erosion and an escalating rate of shoreline retreat (Mimura, 1999; Fletcher and Richmond, 2010). The sea-level near the FSM, measured by satellite altimeters since 1993, has risen more than 10mm per year, significantly more than the global average of 3.2mm per year (Australian Bureau of Meteorology and CSIRO, 2011: 64) (see Figure 2). It is estimated that the mean global sea level will continue to rise over the course of the 21st century, with some studies suggesting faster global rates of sea-level rise (ibid).

At 10 mm per year, sea level rise in Micronesia is much higher than the global average of 3.2 mm

In the Pacific Ocean SIDS, more than 50% of the population lives within 1.5km of the coast (Mimura et al., 2007). This makes residents extremely vulnerable to sea-level rise. Moreover, most infrastructure, social services, tourism facilities, airports, seaport facilities, roads and vital utilities are located in low-lying areas (UNFCCC, 2005: 21). Coastal erosion can, and already is, causing losses and threats to land, communities and vital infrastructure, compromising the socio-economic well-being of those living on islands. Low-lying islands and atolls are the most vulnerable, as they can become totally inhabitable (Barnett and Adger, 2007). Nonetheless, even on islands with large land areas at higher elevations, such as on Kosrae, the majority of people and most of the infrastructure, are located on the narrow low-lying coastal strip. The higher areas are mostly characterised by steep, unstable slopes where development is difficult (Fletcher and Richmond, 2010). In Kosrae, 70% of households live below or seaward of the 4m contour (NIWA, 2013).

Low-lying islands are the most vulnerable, but even on 'high islands', such as on Kosrae, most people and infrastructure are located on the low-lying coastal strip.

Sea-level rise (SLR) is not the only cause of coastal erosion in the FSM, however, and coastal erosion should be seen in the light of multiple drivers. El Niño/La Niña Southern Oscillation (ENSO) climate patterns are considered to be an important factor. The predicted changes of ENSO inter-annual variability as a result of climate change differ among models and remain uncertain (Meehl et al., 2007). Human activities such as reef dredging and sand mining are other significant causes of coastal erosion (Development Review Commission (DRC), 2000). Environmental change is thus the result of multiple drivers and has indisputable human causes (Nelson et al., 2007). Yet, the rise in sea level over the past decades and the rise predicted for the coming decade (Australian Bureau of Meteorology and CSIRO, 2011: 64) are expected to exacerbate the already existing coastal erosion.

Adaptation measures are actions taken by individuals, groups and governments (Adger et al., 2005), to reduce the risk of climate change impact on what is valued (Adger et al., 2009). Over the past decade, there have been a growing number of studies on adaptation to climate change (eg Adger et al., 2003, 2005; Eakin and Patt, 2011; Moser and Ekstrom, 2010; Eriksen et al., 2010). In this article we follow Moser and Ekstrom's (2010: 1) definition of adaptation: "Adaptation involves changes in social-ecological systems in response to actual and expected impacts of climate change in the context of interacting non-climatic changes. Adaptation strategies and actions ... aim to meet more than climate change goals alone, and may or may not succeed in moderating harm or exploiting beneficial opportunities."

Adaptation involves changes in social-ecological systems in response to actual and expected impacts of climate change in the context of interacting non-climatic changes.

Adaptations can be either *autonomous* or *planned* and depending on their timing can be *reactive* or *anticipatory* (Smit and Wandel, 2006: 282; Smit et al., 2001). *Autonomous* adaptations are initiatives by private actors (eg individuals and households) rather than public actors (eg governments and non-governmental organisations (NGOs)) (Leary, 1999: 308; Smit et al., 2001). *Planned* adaptation measures are actions taken by public bodies (eg governments, NGOs) to protect citizens (Adger et al., 2005) and are the result of a deliberate policy decision by a public body (Smit et al., 2001). *Reactive* adaptation measures are triggered by past or current events after some impacts have been experienced (Füssel, 2007). *Anticipatory* measures are based on an assessment of future conditions and are taken before damages have occurred (Adger et al., 2005; Füssel, 2007). The latter distinction is not always definitive, however, as people base their adaptation strategies on their experiences of the present situation and recent past as well as on their expectations of the future.

Adaptation can be planned or autonomos, and reactive or anticipatory

The terms 'adaptation' and 'coping' are sometimes used interchangeably, leading to confusion about the similarities and differences between them. Coping relates to short-term reactions to an extreme-event. Coping strategies are therefore reactive rather than proactive, motivated by crisis and oriented towards survival (Van der Geest and Dietz, 2004; Dazé et al., 2009).

Within the adaptation debate over the past few years, increasing attention has been devoted to the limits of adaptation. Limits of adaptation refer to the point at which an actor's objective (or biophysical) needs cannot be safeguarded from intolerable risks despite adaptive actions (Dow et al., 2013). The debate concerning limits to adaptation relates to a growing awareness in

academic and policy circles that not all climate change impacts can be addressed by current and future mitigation and adaptation efforts, and that in many cases the impacts will exceed the adaptation capabilities of individuals, communities and countries.

Not all climate change impacts can be addressed by current and future mitigation and adaptation efforts; there are limits to the adaptive capacities of individuals, communities and countries

The IPCC Fourth Assessment Report concluded that some impacts of climate change may already be manifest. The impact of climate change *beyond adaptation* has come to be known as 'loss and damage'. Discussions started on the need for adaptation finance and action that would help countries (especially those most vulnerable to the negative impacts of climate change) to adapt and manage loss and damage incurred (Warner and Zakieldeen, 2011: 3). In 2008 at the United Nations Framework Convention on Climate Change (UNFCCC) 14th Conference of the Parties (COP14) in 2008 in Poland the debate on loss and damages intensified as the Small Island Developing States (SIDS) aligned with some of the Least Developed Countries (LDCs) to ask for more attention to be given to the loss and damage they were already experiencing. In 2010, at COP16 in Cancun, it was recognised that joint international efforts were needed to better understand and address such loss and damage.

Loss and damage results from the inability to respond adequately to climate stresses and the costs associated with existing measures

The concept of 'loss and damage' revolves around the question of the extent to which people in vulnerable countries are already suffering from the consequences of climate change, despite attempts to adapt (Warner and Zakieldeen, 2011). It is argued that there are limits to adaptation and that even if adaptation measures are implemented, there will still be residual loss and damage. In this study, which is part of the Loss and Damage in Vulnerable Countries Initiative,[2] 'loss and damage' is defined as "the negative effects of extreme weather events and slow-onset climatic changes that people have not been able to cope with or adapt to" (Warner et al., 2012: 20). This definition includes the inability to respond adequately to climate stresses and the costs associated with existing coping and adaptive strategies (cf. erosive coping strategies and mal-adaptation) (Warner and van der Geest, 2013).

In this review we use the concept of loss and damage to go beyond purely material losses, which is still over-represented in most literature,

[2] For more information on the Loss and Damage project, go to http://www.lossanddamage.net/

and incorporate social and cultural losses (Adger et al., 2013; Morrissey and Oliver-Smith, 2013).

This study addresses the impacts of coastal erosion on the island of Kosrae, the adaptation strategies households have adopted, and their limitations

This study addresses the degree to which households on the island of Kosrae are affected by coastal erosion, the adaptation measures and coping strategies they have implemented, and the limitations of such measures and strategies. Kosrae is one of four states of the FSM; as such, it is not an individual SIDS, but a state within a SIDS and thus shows characteristics in line with SIDS. This empirical case study contributes to the critical debate on the impacts of climate change beyond adaptation in general and within the context of vulnerability of SIDS in particular. This study is part of a series of case studies that empirically assesses climate-change related loss and damage in vulnerable countries. The case studies were undertaken in nine countries: Bangladesh, Bhutan, Burkina Faso, Ethiopia, Kenya, the Gambia, Micronesia, Mozambique and Nepal. Areas for the case studies were chosen on the basis of the diverse set of climate change impacts that have manifested themselves over the past decades; changes in rainfall patterns, droughts, floods, cyclones, sea-level rise and coastal erosion. The Kosrae case study focuses on the impacts of coastal erosion. While the coastal erosion that has occurred on Kosrae to date is due to a complex interaction of both natural and human factors, and not only due to climate change, it is an example of the impacts that coastal erosion can have on a small island state.

These case studies are part of the Loss and Damage in Vulnerable Countries Initiative, initiated by the government of Bangladesh and funded by the Climate and Development Knowledge Network (CDKN). The case studies are coordinated by the United Nations Institute for Environment and Human Security (UNU-EHS). Other partners in the consortium are German Watch, the International Centre for Climate Change and Development (ICCCAD) and Munich Climate Insurance Initiative (MCII). The African Climate Policy Centre (ACPC) of the United Nations Economic Commission for Africa (UNECA) funded the research in three African countries.

1.1 Climate change and loss and damage

Sea-level rise is considered to be an exacerbating factor causing coastal change in Pacific islands that are particularly vulnerable (Mimura et al., 2007). There are many other natural and human factors that also cause or contribute to coastal erosion, for example extreme climate events, the effects of climate variability such as ENSO on wave and water-level processes, and human activities such as coastal defence construction, sand mining and reef dredging (see for example DRC, 2000). In most cases, therefore, coastal erosion cannot be solely attributed to climate change yet it is often perceived to be a significant contributing factor both now and more so for the future (Mimura et al., 2007).

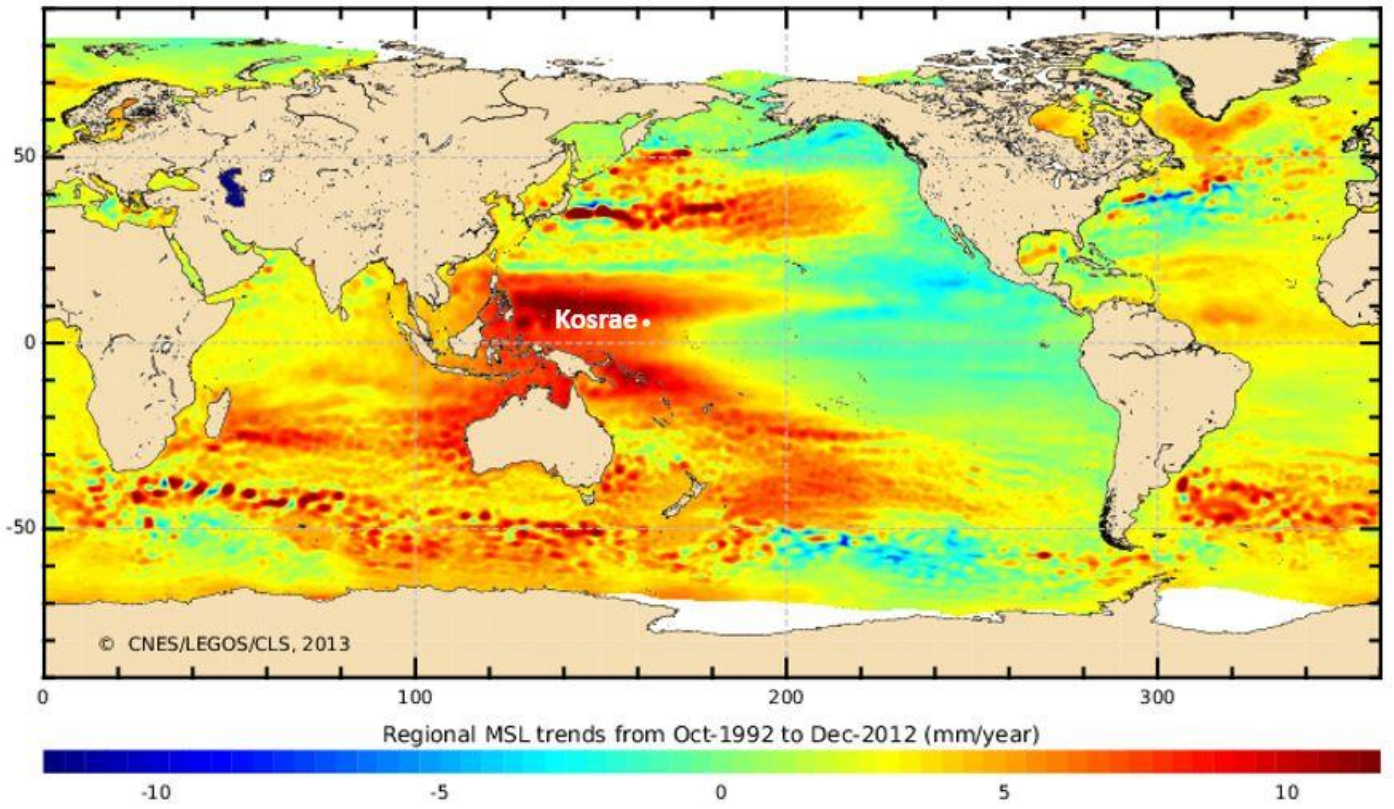


Figure 2: Global distribution of the rate of absolute sea-level rise between October 1992 and December 2012 (mm/year). Source: http://www.aviso.oceanobs.com/en/news/ocean-indicators/mean-sea-level/ in NIWA, 2013.

Coastal erosion is a major concern in relation to the effects of climate change in the region (Mimura, 1999; Mimura et al., 2007; Fletcher and Richmond, 2010). Islands in the region are often low-lying islands with the majority of residents living in areas that can easily be affected by coastal hazards. Narrow coastal plains have provided locations for human settlements and for infrastructure to support social and economic needs – eg social services, tourism facilities, airports, port facilities, roads and vital utilities (UNFCCC, 2005: 21). Coastal erosion therefore presents a considerable challenge to SIDS in terms of managing the effects of dynamic shoreline changes on fixed land boundaries, housing, schools, roads and other infrastructure.

SIDS, containing both high-island and low-lying coastal nations, are on the frontline of climate change. Global mean air temperatures have risen by approximately 0.7°C in the period 1906-2005 and for the next two decades projections are for approximately 0.2°C per decade (Nurse, 2011: 228). During the 20th century, global mean sea levels rose 0.17m ±0.05m (Bindoff et al., 2007), approximately ten times faster than the average rate for the previous 3,000 years (Nurse, 2011: 228). Some regions in the world are, however, more prone to sea-level rise than others and show significantly higher levels of increase in millimetres per year.

Small Island Developing States are on the frontlines of climate change

Figure 2 shows that sea-level rise near the FSM measured by satellite altimeters since 1992 is significantly more than the observed sea-level rise in the surrounding areas. The Australian Bureau of Meteorology (ABM) and CSIRO report of 2011 also indicates that the observed rise in sea level in this region since 1993 is over 10mm per year, and significantly more than the global average of 3.2 ± 0.4mm per year (ABM and CSIRO, 2011: 64). The underlying causes of this do not, however, point solely to the impacts of climate change. This spatial variability is argued to be largely due to trade wind and oceanographic influences and is likely to be predominantly attributable to inter-decadal variability rather than to a higher rate of long-term mean sea-level rise in this region (Meyssignac et al., 2012).

The above average rise in sea level and a higher frequency and intensity of extreme weather can have severe impacts on coastline and population

The fact that sea-level rise is significantly higher in this area than in other areas of the Pacific Ocean gives rise to concern. The rise in sea level and potential increase in frequency and intensity of extreme weather events could significantly affect the already vulnerable coastline and population along the coastline. Relatively small changes in mean temperature can also result in a disproportionate increase in the frequency of extreme weather events (Rosenzweig et al., 2001). Extreme weather events include spells of very high temperatures, extreme rains, and droughts. Under an increasing greenhouse effect, change can occur in both the main climate parameters and the frequency of extreme meteorological events (Rosenzweig et al., 2001; Mirza, 2003). The southwest Pacific Ocean region where Kosrae is located is severely influenced by ENSO climate conditions. The ENSO phenomenon is quasi-regular, tending to recur every two to nine years with varying intensity. The predicted changes in ENSO inter-annual variability as a result of climate change differ from model to model (Meehl et al., 2007), yet analysis of El Niño records shows that events have been stronger and more frequent since the 1980s, a pattern possibly linked to global warming (Rosenzweig et al., 2001). Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions (± 15 cm) during October-February. Over the past years, there have been high solstitial tides with seasonal water levels from October to February in La Niña years (ABM and CSIRO, 2011: 65). On Kosrae this results in high (king) tides. 'King tide' is a popular name referring to any high tide or sea level that is well above an average height. Over the past ten years, local people perceive that high king tides have become more frequent. This is likely the result of a combination of La Niña events (compared to the period prior to 2000), which has pushed sea levels up, and sea-level rise (NIWA, 2013). Long-term sea-level rises will result in high tide levels increasingly exceeding what is currently considered a king-tide level.

People on Kosrae perceive that the frequency of high 'king tides' has increased

It was beyond the scope of this study to focus on establishing a link between increased flooding and king tides and climate change. Doug Ramsey of the National Institute of Water and Atmospheric Research in New Zealand argues that increased flooding is purely the result of La Niña phenomena over the past decade (personal communication). Kosrae is out of the natural hurricane range in the southwest Pacific, yet the impacts of hurricanes in the region are directly experienced in Kosrae. In both Indian and southwest Pacific Oceans there has been a significant increase in the number of hurricanes reaching categories 4 and 5 over the past 35 years (Webster et al., 2005; Hay and Mimura, 2006). Increased impacts on Kosrae can therefore be expected. In this study, we have examined the perceptions of residents in relation to the extreme high tides (king tides) and the coping measures they have carried out. Extreme events mostly occur as a combination of a severe storm with a very high tide (eg as a result of the season and moon) and solstitial tides.[3] Combined with La Niña year, which results in significantly higher seasonal sea level water, these events occur frequently on Kosrae.

Extreme weather events result from severe storm combined with high tide

As loss and damage is a new concept in climate change research, no commonly accepted definition is available yet. However, to inform our research questions and methods, we used the following definition: loss and damage refers to adverse effects of climate extremes, variability and climate change that people have not been able to cope with or adapt to. This definition includes the inability to respond to climate stresses (ie the costs of inaction) and the costs associated with existing coping and adaptive strategies. Such costs can be economic or monetary, but also social and cultural loss and damage.

This study goes beyond purely economic and material losses and damages, and uses qualitative as well as quantitative data

The concept of loss and damage in this study thus goes beyond the narrow interpretation of loss and damage as being purely economic and related to material loss. The case studies make use of quantitative as well as qualitative data, allowing for large-scale comparisons between different impacts as well as providing detailed information on the real impacts of climate change on people's livelihoods. Loss and damage from climate change varies across households, communities and societies according to their level of vulnerability and resilience. The case studies illustrate that loss and damage is also related to mitigation, as the potential costs of future climate change depend to a large extent on the intensity

[3] Solstitial tides are caused by the astrological event of the sun's relative position changing

of climatic disruptions, which in turn depend on mitigation efforts globally.

1.2 Research focus and objectives

Kosrae, one of four states of the FSM, has experienced severe coastal erosion over much of the last 30 to 50 years. Over the last century, and particularly since the end of the Second World War, the four main villages on Kosrae have developed on a narrow coastal strip. Currently, 70% of households live on land that is less than 4m above mean sea level (NIWA, 2013). All are at significant risk from coastal erosion and inundation.

70% of households on Kosrae live at less than 4m abouve sea level

Coastal erosion on Kosrae is the result of complex factors related to natural events around the 1890s and subsequent shoreline changes and to developments along the shoreline, particularly over the past 60-70 years. Ongoing coastal erosion and sporadic inundation have affected homes on Kosrae, primarily due to poor management of coastal development and human impacts on the natural environment. Human activity since the end of the Second World War – such as sand mining of beaches and dredging of the reef flats to build three airstrips, roads, houses, schools and other government buildings – has been a significant cause of the coastal erosion and habitat loss that has occurred (DCR, 2000). Continued building along the shoreline exposes the community to coastal hazards (Fletcher and Richmond, 2010). Both coastal erosion and inundation impacts are expected to increase as a result of climate change (Mimura et al., 2007).

Besides climate stressors, sand mining and dredging of the reef flats for infrastructure have also been significant causes of coastal erosion

This research aimed to investigate the impacts on the homes of Kosrae residents of coastal erosion caused by gradual change as well as by more extreme events such as king tides. In this research, 'loss and damage' also incorporates the negative effects of extreme weather. This study addresses the question: *to what degree do households on Kosrae, Federated States of Micronesia, suffer from coastal erosion, have they carried out adaptation measures, what are the limitations of such measures, and what is the resulting loss and damage.* In this study, loss and damage relates to both monetary and non-monetary values and to gradual changes caused by extreme weather events. Although we acknowledge that coastal erosion affects not only households but also infrastructure such as roads, electricity and government buildings such as schools, this study focuses exclusively on households. Having detailed empirical data to show the actual loss and damage already taking place, and the adaptation and coping measures households have or have not been able to undertake, is crucial for guiding future

policymaking and helping those vulnerable in the region.

The central research question will be answered through a set of sub-questions:

- What is the extent of coastal erosion on Kosrae?
- What is the impact of coastal erosion on Kosrae?
- How vulnerable are different villages on Kosrae to the impact of coastal erosion?
- How vulnerable are different households to the impact of coastal erosion?
- How do households adapt to coastal erosion impacts?
- What long-term adaptations are made in relation to more gradual changes (sea-level rise and associated gradual erosion)?
- What short-term coping strategies do households carry out in response to king tides?
- What type of loss and damage (costs) is incurred as a result of adverse effects of coastal erosion that people have not been able to offset through coping and adapting?
- What is the loss and damage (costs) associated with inability to deal with this impact?
- What is the loss and damage (costs) associated with current ways of dealing with this impact?
- What can be done to reduce loss and damage from coastal erosion?

What losses and damages result from the adverse effects of coastal erosion that people have not been able to avoid with coping and adaption measures?

In order to better understand patterns of loss and damage in Kosrae, this case study will gather data and information in four research domains:

Climate variable: In this study we investigate the impact of coastal erosion on Kosrae. Coastal erosion is primarily the result of non-climatic factors such as natural (eg ENSO events) and human actions (eg reef dredging) but is becoming increasingly strengthened by significant sea-level rise in the region. This study does not aim to investigate the relation between climate change and coastal erosion but rather focuses on the societal impact of coastal erosion. We acknowledge that coastal erosion is also related to non-climatic factors.

Societal impact: We investigate the adverse impacts of coastal erosion on housing, yet wider livelihood impacts also receive attention.

Coping and adaptation: What is done to cope with and adapt to the impacts of coastal erosion? The adaptation measures relate to long-term responses to coastal erosion, whereas coping relates to short-term coping measures in response to extreme weather events.

Loss and damage: What are the limits to coping and adapting to coastal erosion? What loss and damage occurs when a household cannot adapt further (ie when the limits of coping and adaptation are exceeded)? What impacts of coastal erosion have people not (yet) been able to avoid? This includes inability to cope or adapt and the consequences or costs associated with the inability of existing coping mechanisms.

Chapter 2: Methodology

This chapter provides information on the location and methods chosen to answer the research questions raised in section 1.3. Both qualitative methods (in-depth interviews and focus group discussions) and quantitative methods (a questionnaire survey) were used in this research. We administered 363 household questionnaires, conducted six focus group discussions with a variety of stakeholders and 12 in-depth interviews during July 2012. Eight in-depth interviews were conducted with residents who have been affected by coastal erosion and four were carried out with key experts; quotes in this article have been extracted from those interviews.

Figure 3: Location of Kosrae, Micronesia

The research team consisted of 14 people and was led by international researcher Iris Monnereau and project leader Simpson Abraham. Iris carried out ten in-depth interviews, Simpson Abraham two. The 363 surveys were carried out by ten enumerators dispersed over the four different villages. The six focus group discussions were carried out by Simpson and Iris. Ginny Jose and Carlos Cianchini provided ongoing practical support during the duration of the fieldwork (4–31 July). Carlos Cianchini took several photographs for the project; Ginny acted as note-taker and supervised the data entry, which he carried out with support from several of the enumerators. The research location and methods used (questionnaire, in-depth interviews and focus group discussion) are discussed in more detail below. This is followed by a brief examination of the limitations of this research.

2.1 Research location

Kosrae is one of the four states of the Federated States of Micronesia (FSM). The FSM is located in the western north Pacific Ocean. The total land area of the 607 islands of the FSM is approximately 702km². The small land area contrasts with the size of the Exclusive Economic Zone (EEZ), which totals over 2.98 million km² (ABM and CSIRO, 2011). In comparison to the other states of the FSM that consist of more than one island, the state of Kosrae consists of only one island, Kosrae, and a very small near-shore island called Lelu, connected to Kosrae via a causeway. Lelu is only 2km² in area, but has a population of around 1,500. Kosrae is located approximately 600km north of the equator, between Guam and the Hawaiian islands.

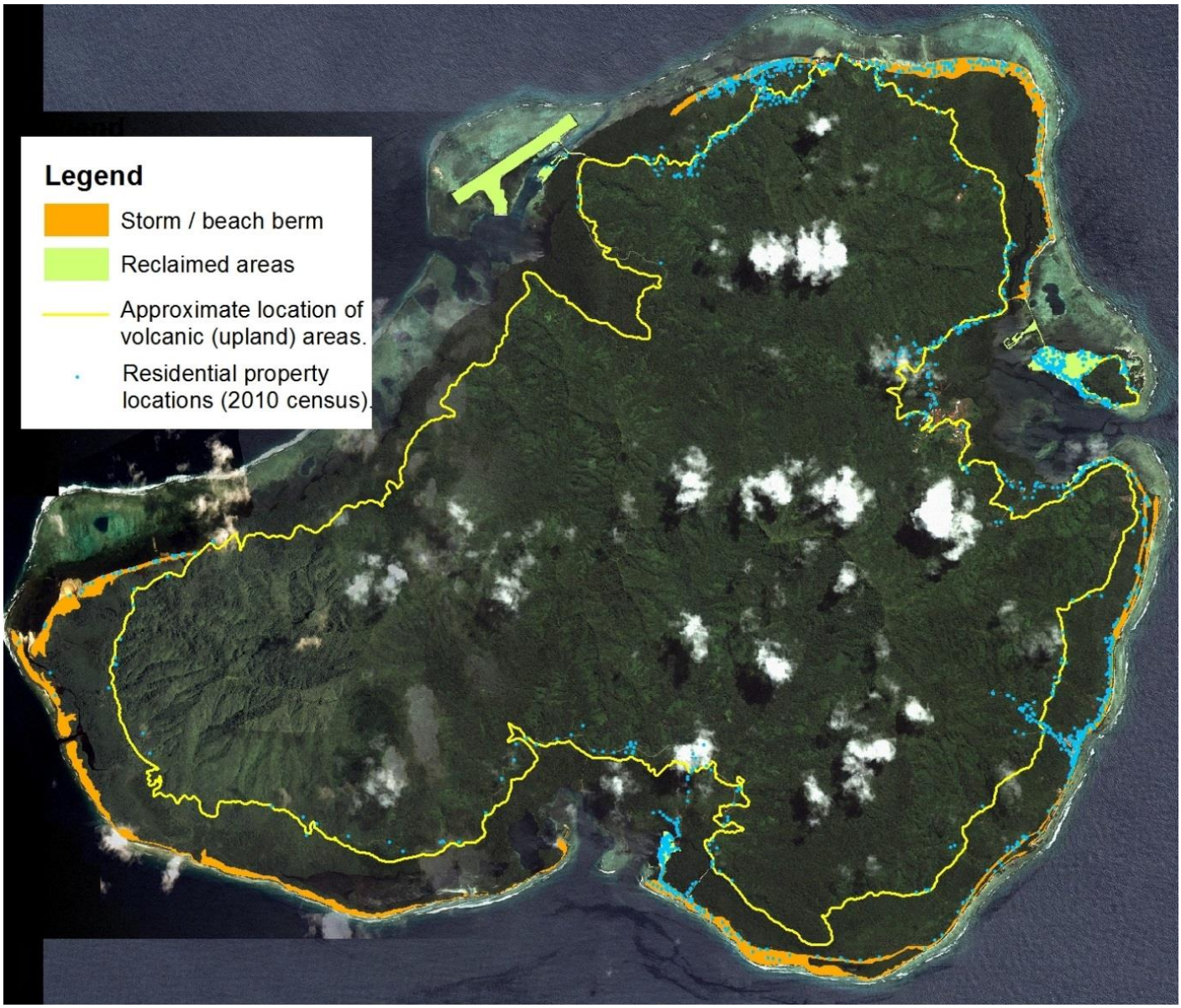


Figure 4: Location of residential development on Kosrae. Source: NIWA, 2013

Kosrae is a small volcanic island of 110km² covered with a dense vegetation. Basaltic mountains rise to a maximum elevation of 628 metres, and deep valleys characterise the slopes. There is a large outer-ring of low lying coastal area. Although Kosrae is thought to be safe from rising sea level because of its elevation in comparison to low-lying atolls with no or hardly any elevation, the majority of residents on Kosrae live in the low-lying coastal area. The population is 6,616 (2010 census) and 70% of all households are within 4m above sea level (NIWA, 2013) – nearly all of them within the low-lying coastal area of 4m above sea level (DRC, 2000). Figure 4 shows household locations with blue spots. The majority are located close to the shoreline. Much community and infrastructure development such as roads, electricity and telecommunication on Kosrae over the last 60 years has occurred along the coastal margins. These low-lying coastal areas are prone to long-term shoreline change and occasional coastal inundation (particularly during

times of king tides). Kosraeans have also built in some areas such as Lelu (island) and Malem on reclaimed land.

Houses built on reclaimed land, Lelu.
Photo: Iris Monnereau

Over the past century, Kosrae has been ruled by several countries, which have left their legacy on the island. The Germans entered Kosrae after the Spanish-American war in 1898 and ruled for 15 years. The island came under control of the

Empire of Japan after World War I until 1945. With the peace agreement at the end of World War II, the United Nations put the United States in charge of the social, economic and political development of the former Japanese colonies of the Western Pacific, including Kosrae, and a slow process of Americanisation in the region began.[4]

The FSM is currently one of the Freely Associated States with the political relationship (Compact of Free Association) with the United States. In 1979, the FSM became a UN Trust Territory under US administration. On 3 November 1986 independence was attained under a Compact of Free Association with the US. The UN formally ended the trusteeship in 1990 and the FSM became a member of the UN. The Compact was renewed in 2004, implying that Kosraeans can work, study and live in the US.

In terms of development, the FSM ranks much higher on the Human Development Index than the other case study areas in the Loss and Damage project.[5] The FSM ranks number 116 (out of 187 countries) and is thus considered a country at medium level on the human development index. Bhutan is the first country to follow Micronesia at the 141th place, falling also in the medium level category (albeit as the last one). The other six countries are all ranked in the low human development category: Kenya (143), Bangladesh (146), Nepal (157), The Gambia (168), Ethiopia (174), Burkina Faso (181) and Mozambique (184). The last implies Mozambique is the fourth last country in the world.

Typhoons events are rare on Kosrae, but they have played a significant role in the shoreline

[4] http://www.kosrae.com/History.aspx Accessed 4-11-2012

[5] The HDI is a single statistic to show both social and economic development of a country. The scoring is an aggregate of life expectancy, level of education, GDP per capita (adjusted for inequality). see http://hdr.undp.org/en/statistics/ihdi/ for more information as well as ranking of countries.

changes experienced around the coastline of Kosrae. The last cyclone to have significantly affected Kosrae was in 1905. Yet, it was a typhoon in 1891 that was of particular importance. Despite the fact this typhoon caused a lot of damage, it did deposit a large bank of coral rubble onto the reef flat along much of the eastern coastline as well as sand and coral rubble onto the beaches (Development Review Commission (DRC), 2000). The coral rubble bank provided a sheltered environment from wave action in its lee, allowing mangroves to establish and the shoreline to build out along the eastern coast. Over time, this rubble bank has worn down, accelerated by the removal of large amounts of coral rubble for construction in the decades following World War II. The progressive loss of the sheltering effect of the bank has increasingly allowed more wave energy to reach the shoreline, resulting in a loss of mangrove habitat and a landward retreat of the east-facing shoreline (DRC, 2000; Doug Ramsey, personal communication).

Gradual coastal erosion threatens housing along the coastline in Malem, July 2012 (Source: Doug Ramsey)

December 2008, king tide inundating coastal communities along the north and northeast side of Kosrae.
Source: Kosrae Island Resource Management Agency staff)

2.2 Household questionnaire

The 363 households were chosen on the basis of a 100% sample of 374 households living within approximately the first 60 metres of coastline and in one river-mouth area. Eleven households were unavailable to complete in the questionnaire. The total number of households on Kosrae is 1,170, with a total population of 6,616 (census 2010). Ten enumerators interviewed the households. Two to three enumerators were allocated to each village, typically in the villages where they themselves lived. Towards the end of the research, enumerators in the villages of Malem, Utwe and Tafunsak helped conduct the surveys in Lelu. Two enumerators travelled to the village of Walung, which is only accessible by sea. The questionnaire (Appendix A) contained both open and closed questions and usually took between 30–70 minutes to complete. Table 2.1 summarises the number of household questionnaires completed in each village.

Village	Number of questionnaires
Utwe	82
Lelu	230
Tafunsak	63
Walung	31
Malem	57

Table 2.1 Number of questionnaires per village on Kosrae

In 86% of the cases, it was the household head or their spouse who was interviewed. In the remaining cases it was usually a son or daughter of the household head (older than 16 years). The survey consisted of four sections and consisted of both open ended as well as closed questions. In the survey, we first gathered basic demographic and socio-economic information of the household. Then we inquired about the impacts of gradual changes in coastal erosion over time, the adaptation measures people adopted and the effectiveness of these measures. Adaptation is defined and explained to respondents as longer-term responses to more gradual changes, while coping strategies were defined as short-term responses to the impacts of sudden events and thus refer to more temporary, ad hoc, responses (Warner et al., 2012). Finally, we asked about impacts of more extreme events like storms and coastal floods over the past 20 years and households' coping strategies. Sections 2 and 3 of the questionnaire started with open-ended questions to gather people's own perceptions of the climate stressor as well as potential changes, impacts, and adaptation or coping strategies. This was followed by closed question gathering, *inter alia*, information about impacts on crops, livestock, fishing, trade and housing and frequent adaptation strategies, that is, in relation to agriculture, livelihood diversification and human mobility. The closed questions enabled a quantitative analysis of results.

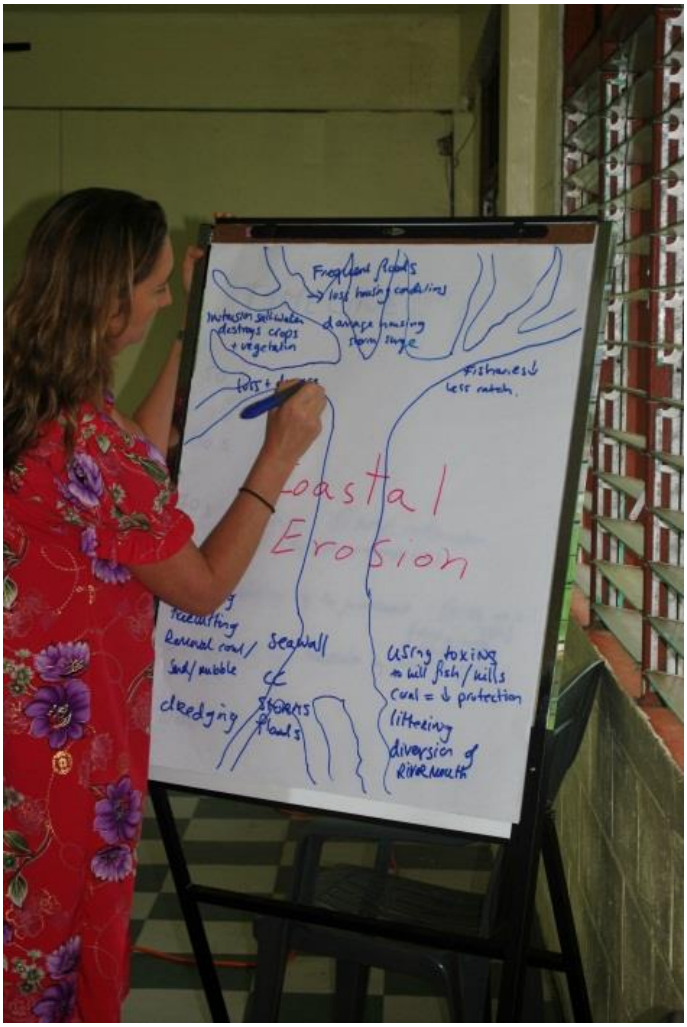
2.3 In-depth and group interviews

We conducted 12 in-depth interviews during July 2012. Nine in-depth interviews were conducted with residents who have been affected by coastal erosion. Enumerators identified the people for interview after they had conducted a survey with them or they were brought to our attention through focus groups discussions. Three in-depth interviews were carried out with key experts (a state senator; a staff member of the Kosrae Conservation Safety Organisation (KCSO), an NGO; and a government employee working for the Kosrae Island Resource Management Authority). (see Appendix B).

2.4 Focus group discussions

Three different focus group discussions were held with stakeholders, the Senate of Kosrae, and the Kosrae Island Resource Management Authority (KIRMA) (a semi-autonomous government agency) (see Appendix C for a list of the focus group discussions). These three focus groups were attended by both young and old citizens but not women (except for Iris Monnereau). During these meetings, Iris Monnereau presented an overview of the loss and damage project, and Simpson Abraham further explained the details of the project and acted as facilitator. This was followed by a discussion on the project and coastal erosion on Kosrae. See Appendix C for the dates of each focus group discussion and the minutes of each meeting.

Focus group discussion with Lelu senior citizens. Photo: Carlos Cianchini



Research drawing 'problem tree' during a focus group discussion. Photo: Carlos Cianchini

Three further focus group discussion were held with the senior citizens of Malem, Lelu and Utwe. These involved both men and women and were well attended. Focus group discussion were not carried out in Tafunsak or Walung due to time constraints, which also limited the potential for other focus group discussion – eg with young people or women's groups. Given the time limitations, it was decided that the senior citizens were best suited to provide a clear picture on the developments and changes that had taken place along the coastal margins over the past 50 years.

A 'problem-tree' approach was used, focusing on the causes and impacts of coastal erosion. The problem tree was filled in with comments from participants and their views on causes, impacts and solutions to coastal erosion in their village. In addition, Iris and Simpson established, with the focus group, a timeline of events that had led to the current problem of coastal erosion in their village.

2.5 Research limitations

The household surveys were conducted with 65% male and 35% female respondents. In principle, interviews could be carried out with either female or male household heads, yet when both household heads were present, it tended to be the man who completed the survey. Furthermore, in a number of cases when only the female was present in the household they would tell the enumerators to come back later when their husband would be at home. The surveys thus have a small bias towards a male perspective. As mentioned in Section 2.4 during the three different focus group discussions with the senate, policymakers and KIRMA there were no female participants, again meaning there is a bias towards a male perspective.

The ten enumerators were fluent in Kosraean and conducted the surveys in Kosraean, yet they struggled to read or write Kosraean. They would conduct the verbal part of the survey in Kosraean, but write it up in English. Using one language might have been easier for the enumerators and less time consuming but would have limited responses in some cases.

Another constraint was the short time available for the research. The fieldwork period was very short (4–31 July). The team completed nearly all surveys in the sample, yet it would have been good to have more time for in-depth interviews with key experts and focus group discussions with different age groups. If more time had been available we would have had more time to test the survey and make improvements before carrying out all 363 surveys.

In this study, we do not differentiate (and, indeed, it is not possible to do so) between ongoing natural and human-related influences on coastal changes on Kosrae and any exacerbating effects due to climate change. We realise that making a distinction is difficult and this will have influenced the answers respondents gave.

Islands in the Pacific Ocean report not only erosion and loss of land but also accretion of land (Webb and Kench, 2010). Although accretion might take place on Kosrae, we have not investigated this or incorporated questions on accretion of land in Kosrae in the survey.

Chapter 3: Livelihoods, employment and housing in Kosrae

3.1 Main sources of livelihood and vulnerability

This chapter describes the main characteristics, sources of livelihood and housing characteristics of the respondents to the survey. The household surveys were conducted among the households living in close proximity (< 60m) to the coastline and, in Malem, the river banks. Table 3.1 shows the characteristics of the respondents. The average age of respondents was 49.9 years; only three people interviewed were under 20 years of age, four were over 80. On average, there were 6.7 people per household, with 1.8 economically active people per household. Respondents had an average of 5.1 children per household (2.6 sons and 2.5 daughters). Most respondents were male (65%), compared to females (35%) (see Section 2.5 for more on this division). Christianity is the sole religion on the island, although many different Christian denominations are practised. The first missionary post was established by Protestant missionaries in 1852, and virtually the whole island converted to Christianity within a few decades. Religion still plays a very important and central role in Kosraean society.

All respondents were of Kosraean nationality with the exception of two. The average number of years of education among Kosraeans is relatively high at 12 years, which means the majority of respondents attended school until they were, on average, 18 years of age. This high level of education is in line with general statistics from Micronesia, which has a primary-secondary gross enrolment rate of 98% (United Nations Statistical Division, 2010). English is the official language of the FSM. Kosraeans mostly speak to one another in Kosraean although they are less proficient at reading and writing in Kosraean. The US dollar is the official currency.

Characteristics of respondents	% / Years
Male	65%
Female	35%
Single-headed household	12%
Christian	100%
Average years of schooling	12 years
Average age of respondent	50 years

Table 3.1 Characteristic of respondents

Category of non-farming income	%
White collar	48
Blue collar	23
Petty trade	20
Processing of natural resources	3
Crafts	3
Large business	3
Total	100

Table 3.2 Categories of non-farm activities

Table 3.2 shows the main sources of paid income of households. The main source of income comes from non-farm activities (59.1%) (see Table 3.3). On average one person per household was involved in non-farm income (NFI) activities. The main categories of NFI income are white collar

work (48%), blue collar (23%) and petty trade (20%). White collar jobs include teachers, nurses, bank clerks, computer technicians and sales assistants. Blue collar work includes plumbers, electricians, cooks and construction workers.

Remittances are the second largest source of household income (in both money and goods), with 64% of respondents indicating that their household received remittances. As the FSM has a constitutional government in free association with the United States, Kosraeans are able to freely work, study and live in the US. Remittances are typically sent by Kosraean family members living on either the US mainland or the islands of Guam and Hawaii. Only four respondents out of the 234 who indicated they received remittances, received them from outside US territories (China (2), Japan and Germany). Most remittances were sent by sons, followed by daughters, brothers, sisters and other relatives (eg cousins). The remittances are a significant component of household income, with the average amount sent per household being US$1,087. In addition, a further 137 households received products from relatives abroad (often in addition to the money sent). The average value of products sent to Kosrae was US$450 per household. Together this amounts to US$1,537 per household and represents 20.9% of total income (see Table 3.3). Other sources of income (23%) mostly relate to retirement pensions.

Kosrae households engage in agricultural activities such as cultivating crops (71%), growing fruit trees (74%), fishing (70%) and raising livestock (71%) (see Table 3.3). The produce of these activities is mainly used for household purposes, however, and does not comprise more than 3% in terms of income generation (see Table 3.3). The main sources of income on Kosrae thus come from non-farm activities (59%), including white collar work, blue collar work and petty trade.

Category	% of households	N=	% of income
Non-farm activities	68	247	59.1
Remittances (money and goods)	64	234	21
Other sources	23	85	9.2
Crop cultivation	71	256	3.1
Tree crops	74	269	2.5
Fishing	70	252	2.1
Livestock	71	256	1.6
Farm labour	4	15	1.5

Table 3.3 Employment of respondents (not exclusive)

Crop production and tree crops mostly consist of taro (a root vegetable), bananas, breadfruit, papayas and coconuts. Respondents were also growing cabbage, mango trees, tangerines, cucumber and eggplants. Some grew kava roots (used to make the alcoholic drink Sakau) and betel nuts. Betel nuts, also known as areca nuts, from the areca palm (Areca Catechu) are chewed by many inhabitants of Kosrae and are considered to be a mild stimulant.

Only four respondents used animals or tractors to plough their land. Irrigation is used by 18% of all respondents (this is low-key irrigation, ie watering crops), and by 42% of those engaged in farming. Crop cultivation is mainly carried out for

household consumption; only 3.3% of respondents stated the main purpose of production was for sale. The total average sales of agricultural produce is US$226 per year per household. Crops grown mostly consisted of bananas, cabbage, taro and sugar cane. Twenty-five per cent of respondents said crop yields were decreasing a lot, and 15% said they were decreasing a little. The main reason given for this decrease was saltwater intrusion. No direct distinction was made in the survey, yet most answers related particularly to banana and taro production being affected by saltwater intrusion.[6] Approximately 47% of the households indicated that crop yields remained the same, whereas 11% indicated crops were increasing a little, and 2% indicated they were increasing a lot. The main reasons given for the increase was increased farming activities (planting or more land).

Crop cultivation is carried out in the coastal areas where the household lives but primarily in the uphill areas where families often own land. No estimate was made of the split between produce grown at the household and that grown on upland farms. However, a considerable amount of farming is conducted in the uphill areas where there is no saltwater intrusion or coastal inundation.

Seventy-four per cent of the households own a number of tree crops, such as oranges, lemons, breadfruit and coconuts. Of those, 91% indicated that tree crops provided an average income of US$187.

Seventy per cent of the respondents were engaged in fishing. Considering Kosrae is located in the middle of the Pacific Ocean and has a large and healthy coral reef (ABM and CSIRO, 2011) this is no surprise. National fish consumption is estimated to be 69kg per person per year, which is considerable considering the average for Oceania is 24.6 and for the world 18.8kg (FAO, 2012). In 99% of the households that fished, fishing involved marine capture, whereas fish farming is limited. Of those engaged in fishing, 93% indicated this was mainly for household consumption, with the remaining 7% indicating fish capture was mainly used for sale. Average income per household from fishing is US$158.

Livestock raising is carried out by nearly 71% of the households interviewed, with respondents raising pigs, fowl and dogs. Pig rearing was the main livestock activity; 67% of all households own pigs, with an average number of four pigs per household. Approximately 15% of the households surveyed owned fowls, with an average of nine fowl per household. Only 18 households, equivalent to 5%, said they raised dogs, with an average number of three dogs per household. Of those who owned livestock, 93% said the main purpose was household consumption; only 5% said livestock were intended for sale; the remaining percentage was fowl used for cockfights. The average income of livestock rearing was US$112.

[6] The survey template did not make a distinction between annual and perennial crops.

Respondents estimated that the total income at their disposal is US$7,370. The average GDP per capita for the FSM was considerably lower in 2010 and valued at US$2,434 (UN Statistical Division, 2010). Although this study covered only 363 households on Kosrae and did not cover households living further from the shoreline, the survey results indicate that compared to GDP per capita of the FSM as a whole, the income of Kosrae households is most likely higher than in other FSM states. Yet the majority of respondents (65%) believed their income was average; 23% believed their household income was below average and 12% believed it to be more than average. As an indication of their relative high income in comparison to other countries, most households owned TVs, a fridge, phones and cars (see Table 3.4). The main assets owned by households were TVs (73%), fridges (71%), cars (60%) and phones (58%). Computers were also quite common (41%); 27% owned a bicycle and 3% a motorcycle.

Assets	Percentage of house-holds that own this asset
TV	73
Fridge	71
Car	60
Phone	58
Computer	41
Bicycle	27
Motorcycle	3

Table 3.4 Household assets

3.2 Housing and household property

On Kosrae most households own the property where they live (91.2%); 88.1%[7] own the house they lived in. The average land size on which respondents lived was 2,089m²; the average size of the farmland was 1,428m².[8] Sixteen per cent of respondents owned another house as well. Houses on Kosrae are typically built with iron sheet roofs and cement walls. Iron sheets for roofing is used by 70% of households, followed by concrete roofs (33.2%) and roofs made of natural product (8%). Some houses have roofs made of more than one material of the three above. Cement walls are used by 85%, followed by wood (32%). Only in a few cases is natural material used for the walls. Some households use cement for the first 80cm of the walls to make the house more resistant to flooding. Floors are typically of concrete (94%), with 9% timber. A number of households have both types of floor in their house. On average, houses have 2.4 bedrooms. The majority of houses have electricity (93.4%), leaving only a small number of houses (6.6%) with no electricity; 99% have a WC or latrine.

3.3 Food and food security

As described in Section 3.1, the majority of households engage in crop cultivation, livestock raising, fishing and growing economic trees to supply the household with food. This is in line with the findings that over 60% of the households

[7] N=363

[8] N= 248 (of a total of N=256 respondents who indicated they engaged in farming).

indicated that only half or less than half of the food they consumed was bought; 37% bought more than half of their food. Commonly, families eat 3.1 meals a day, with children eating the same number of meals as parents. Although food appears to be abundant due to families engaging in many farming activities, 21% of the households had suffered from food shortages over the past 12 months; 29% had suffered from food shortages over the past ten years. The main reason given for food shortages was financial difficulties.

A house made of traditional woven mats made of natural material. Photo: Iris Monnereau

A common Kosrae house with cement walls and iron sheet roofing. Photo: Iris Monnereau

Chapter 4: Loss and damage from slow onset climate changes

4.1 Slow-onset climate changes

Kosrae has experienced severe coastal erosion over the past decades (DRC, 2000; Fletcher and Richmond, 2010). The entire coastline of the island has experienced a rapid change, primarily caused by an insufficient amount of sediment on the beaches and a reduction in the protection of waves provided by coral rubble deposits on the outer reef flat. The resulting coastal erosion can be attributed to natural factors; however, human activity has significantly exacerbated the rate of erosion (DRC, 2000). During the second half of the last century, demographic changes, development needs and changes in construction practices exacerbated coastal erosion. Dredging of the reef flat, sand mining, cutting trees and mangroves, building inappropriate coastal defences, land reclamation and altering river outlets all significantly increased beach retreat (NIWA, 2013). The most significant of these activities was the removal of coral rubble from the outer reef flat for use in road and airstrip construction and other development projects (DRC, 2000).

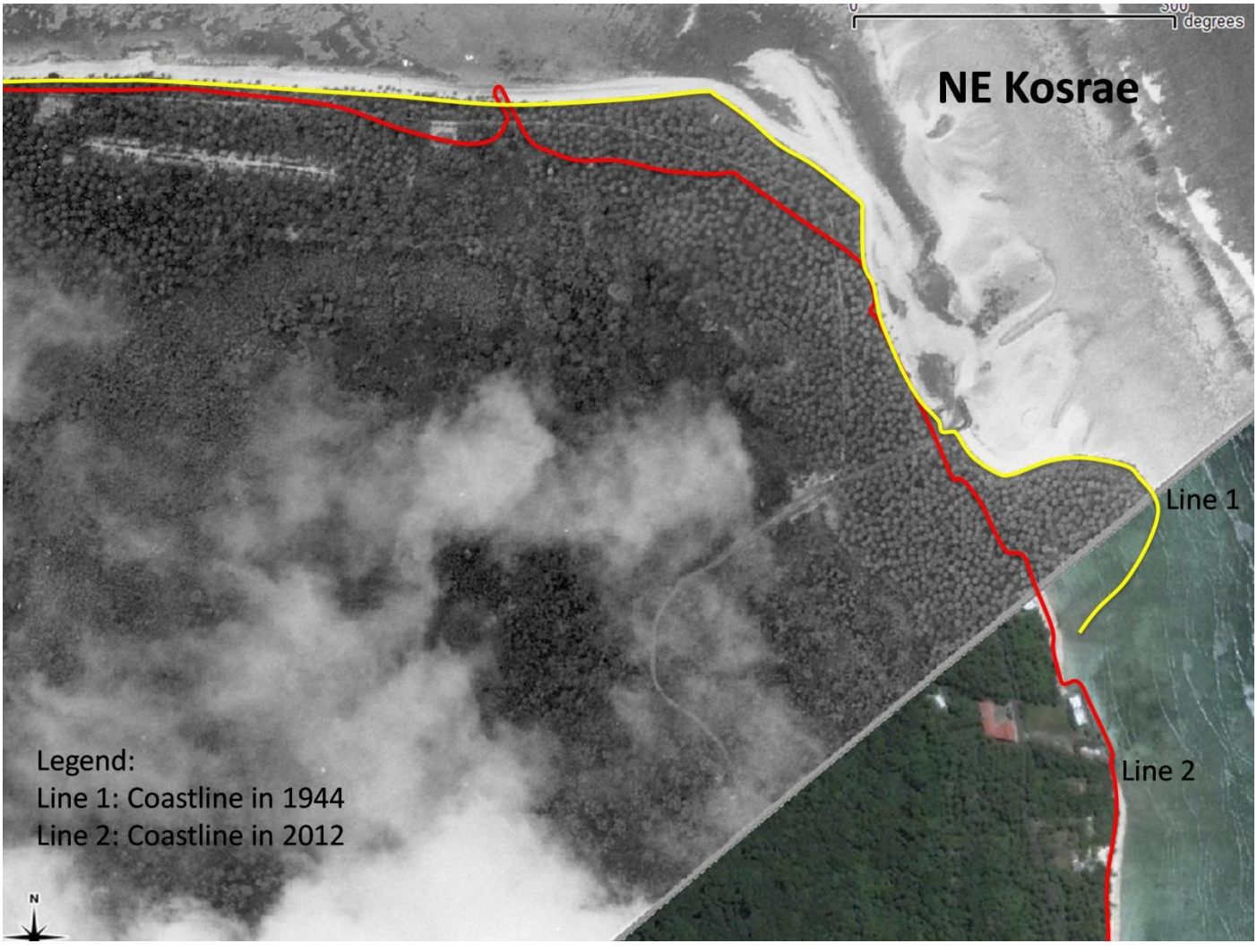


Figure 5: Change in coastline on the north-east corner of Kosrae between 1944 and 2012. Source: Webb, 2012

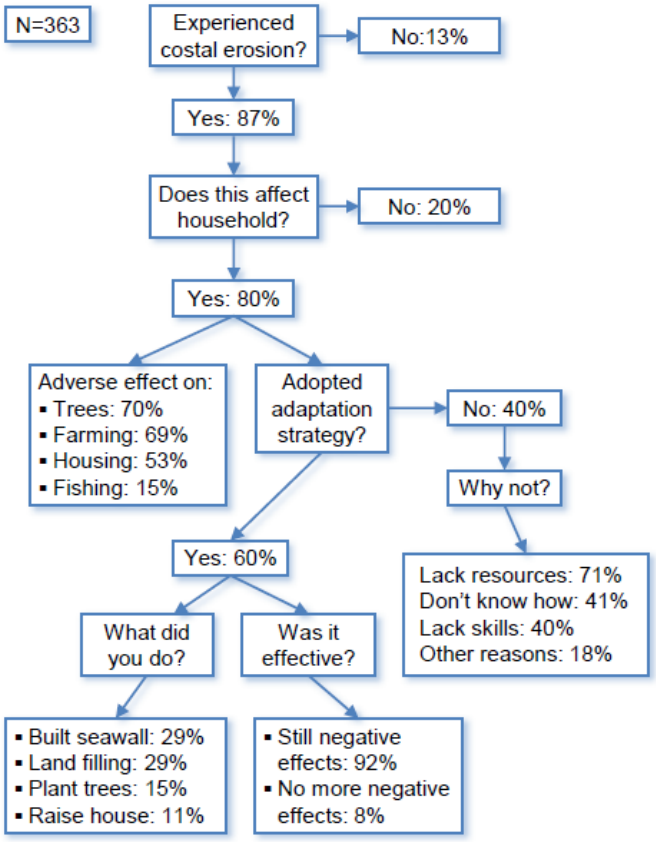


Figure 6: Tree diagram of experience and impacts of coastal erosion on Kosrae

The volume of coastal aggregate necessary to build an airstrip is enormous and while this aggregate can be easily extracted within a few months or years, its replacement in natural carbonate systems will take hundreds of year (Maharaj, 1998). Three different airstrips have been built over the past 40 years, requiring a substantial amount of aggregate, a large part of which was taken from coral reefs surrounding the island. The removal of this large amount of aggregate on other smaller islands in the FSM showed that it causes an increase in near-shore water depths and removes natural coral breakwaters, thereby reducing the amount of natural protection and wave-breaker protection (Maharaj, 1998).

Removal of aggregate in the area of Tafunsak for construction of an airstrip resulted in severe coastal erosion on this part of the island. The devastating effects were so great that the US company responsible for the removal has had to pay residents in the area for their lost land. Although these activities took place decades ago, the impacts are still noticeable. This coastal vulnerability is further exacerbated by the impacts of climate change. Figure 5 shows the loss of coastline between 1944 and 2012.

The picture in Figure 5 is an overlay of two images, one an aerial photograph taken in 1944, the second a satellite image of the same area in 2012. Line 1 shows the coastline in 1944, line 2 the coastline in July 2012, clearly showing the significant loss of coastline. We did not investigate the possible accretion of land on Kosrae. Land accretion has taken place on a large number of islands in the Pacific (Webb and Kench, 2010) so it is possible that similar developments have taken place on Kosrae. The most recent NIWA report on coastal erosion on Kosrae does not state any areas where accretion has taken place (NIWA, 2013).

The majority of survey respondents (87%) have experienced adverse effects of coastal erosion over the past 20 years (see Figure 6). This is in line with reports on coastal erosion on Kosrae (DCR, 2000; Fletcher and Richmond, 2010; NIWA, 2013). Within this group, 60% indicated that this has affected their household, with main impacts on commercial trees (70%), farming (69%) and housing (53%). In relation to damages to their

homes, respondents said, for example: "The shoreline has gotten closer to our house, which increases the risk of water intrusion and flood";[9] "My farm and garden were eroded and I can't do any farming anymore";[10] and, "A large portion of our private land is lost and several of our tree crops are gone."[11] Nearly all the respondents said the reduction in crops and economic trees was due to saltwater intrusion; a few cited decreasing land size.

Fishing has been affected by coastal erosion, sea-level rise and increasing sea temperatures, according to 15% of the respondents, who believe fish catches have been affected because "fish living in shallow areas have died due to high water temperature". They also indicated that there are fewer fish than before and their catches have declined as a result. Rooston Abraham, former fisheries officer of Kosrae, explains the impacts of coastal erosion on fishing activities in the village of Utwe, on the south coast of Kosrae (see Box 4.3). Utwe has a river mouth that serves as a spawning ground for fisheries.

Nine per cent of respondents believe that trade had also been affected. Katarina Adams, a hotel-owner on Kosrae told us how her livelihood has been affected by increasing coastal erosion (see Box 4.4). She moved to Kosrae 17 years ago and built ten beachside cabins made of natural material.

Box 4.1 "I have seen the changes on the coast very well (...) here on Lelu Island (...). There used to be a little island in front of our house, called Rabbit Island. As long as the island was there it was protecting our backyard. Over the last ten years the island has been disappearing slowly and now the sea just slams into our yard. When the tide is high the water comes right up to the road. We have built seawalls to protect us but it's getting worse." (Marston Weston Luckymis, male, 33 years, Lelu, 26 July 2012).

Box 4.2: Hotel owner Katrina Adams describes her experience: "Only six years ago I finally accepted coastal erosion was really destroying our place. At first I was in denial, I just didn't want to see it. When a scientist was here eight years ago I would keep on showing him places where new sand had been deposited as I just didn't want to see what was happening to my home. But six years ago I couldn't deny it any longer. The log of the tree you can see in the water now is the tree we used to sit on in the evening after a day's work. Now more than ten metres of our beach have been destroyed since we moved here and the cabins we have for our hotel in the front have washed away entirely." (Katrina Adams, female, 64, Lelu, 18 July 2012)

[9] Alek Alokoa, Male, 63, Malem, 8 July 2012

[10] Sadako Sanney, Female, 36, Tafunsak, 13 July 2012

[11] Jacob Palik, Male, 63, Walung, 25 July 2012

Box 4.3: "We all depend on fish for our food, but the fishing in Utwe has declined because the river flow has changed. As a result of coastal erosion the little island in front of the village has disappeared, and all the protection of the river mouth disappeared. Now the saltwater is coming straight into the river and affecting the spawning areas of the fish. The lack of brackish water is thus affecting the fish stocks and the fish catch has gone down." (Rooston Abraham, male, 60 years, Lelu, 20 July 2012)

One of the cabins at Katrina's hotel by the beach and the gabion that she placed in front of it filled with rocks and dead coral (box 4.2 and 4.4). Photo: Carlos Cianchini

Box 4.4: Katrina explains how coastal erosion has affected their business: "We are the first hotel on Kosrae and have built cabins right by the shore. As a result of the erosion we have had to abandon two cabins because the water comes right up to them now. The erosion causes the roots of the trees to disappear. When the trees fall down, the wind hits the cabins directly. Changes used to be gradual but over the past months it has become increasingly bad. In December, a European couple stayed here in the hotel for their honeymoon. The entire place was flooded so they had to wade to get out of the hotel, inside their cabin or to the restaurant. Then one night during a storm their roof was blown off because the erosion had damaged the trees, which usually break the wind. They came to us with big eyes and told us their roof had simply blown off. We gave them a new cabin but the next night the giant tree standing next to the cabin simply fell down because the saltwater intrusion had caused the roots to die. Thankfully it fell between two cabins and no one was hurt. I am sure they will never forget their honeymoon." (Katrina Adams, female, 64, Lelu, 18 July 2012)

4.2 Adaptation measures

The following section explores the adaptation measures that households have carried out in response to the challenges of coastal erosion over the past decades. As explained in the introduction of this report, adaptations can be either *autonomous* or *planned* and depending on their timing they can be *reactive* or *anticipatory* (Smit and Wandel, 2006: 282; Smit et al., 2001).

Our survey showed that 60% of households that were affected by coastal erosion said they had carried out adaptation measures (see Figure 6). Building seawalls, gabions and landfilling were the most popular measures, although they were commonly carried out in a haphazard manner. Few were planned, designed or carried out in a collective manner. The most popular adaptation measures were (N=140):

- building seawalls (29%)
- landfilling (29%)
- planting trees (15%)
- elevating housing (11%)
- relocation (6%).

Seawalls are made of rocks, logs, car tyres or other material built to protect houses from inundation and coastal erosion. Gabions are cages of net or metal wire filled with rocks or other types of material (including, for instance, fuel or paint drums filled with cement). Gabions are used to stabilise shorelines and slopes against erosion. Landfilling is carried out by building a small wall (eg of cement) or dam then filling it with dirt, rocks and earth to create more land or to reclaim lost land. Material resources to carry out adaptation measures are scarce, so households have to make do with whatever material they can put their hands on. Respondents described their efforts in the following ways:

- *"I built a 5-foot high 80cm-thick sea wall"* (Nena Likiak, male, 66, Malem, 16 July 2012)
- "I planted coconut trees near shoreline to hold the soil" (Kemela Palik, female, 59, Lelu, 18 July 2012)
- "I used logs, rocks and other debris to fill in the eroded areas" (Kenye Nena, female, 42, Walung, 27 July 2012)
- "I filled the land with rocks, and then poured cement on top of the rocks" (Daniel Thomson, male, 66, Lelu, 11 July 2012)

In addition, 2% of respondents referred to planned adaptation measures: ie collective and state efforts to build seawalls. In the back, is a small lower seawall that was planned and carried out by the Tafunsak restoration project. This is a good example of the variety of seawalls found on Kosrae.

Seawall covered with cement to protect a house in Lelu, Kosrae. Photo: Iris Monnereau

Box 4.5: "In 1971 we built the first seawall from coral reef rocks. Only 15 years later we had to build a new seawall as the water just kept on rising. Groups of men built these two walls as a community. In 2004, the last seawall was built by the government. Large trucks delivered the rocks. But the seawall changed the current and we lost all of our beaches. We used to have a very large beach – this has now disappeared. The seawall we have is not enough and when it floods the water still comes right up to the house. Our bakery floods every year and it wasn't like that in the past. To improve the situation, my wife and I decided to use our own money to make the seawall in our backyard higher. I bought 150 bags of cement. Not all at once – every month I would buy a few bags and cement the area in the back. It cost 500 US dollars – as much as we make in the bakery in three months. But now we feel safe for a while."
(Kilafwasru Kilafwasru, male, 64 years, Malem)

The seawall behind the house and bakery of Kilafwasru Kilafwasru and Sepe Kilafwasru in Malem (box 4.5). Photo: Iris Monnereau

Kilafwasru Kilafwasru and Sepe Kilafwasru in Malem (box 4.5). Photo: Iris Monnereau

The example in Box 4.5 shows how an adaption measure can be autonomous and planned, as well as reactive and precautionary. The first two walls were built collectively by residents, the third was built by the state and the fourth adaptation measure (raising up and fortifying a small part of the existing seawall) – was an individual initiative. It is both reactive and precautionary as it aims to protect from current coastal erosion as well as from future erosion and flooding.

In addition to the autonomous measures that householders have undertaken, several planned adaptation measures have been carried out. The planned measures were mostly carried out

between 2002 and 2005. The state of Kosrae organised and paid for the building of seawalls, mostly of armoured rock, although on occasion the state was supported by external agencies. These seawalls not only have high investment costs, they also typically have high maintenance requirements and have a limited time-span of around 20-30 years (NIWA, 2013). Building new coastal defences will further burden the state and individual municipalities, which are already responsible for funding the upkeep of existing seawalls (NIWA, 2013).

Stone wall in Tafunsak. Photo: Iris Monnereau

A self-built gabion (metal frame filled with rocks) in Malem: Photo: Iris Monnereau

Seawall of cement bags in Lelu. Photo: Iris Monnereau

Residents undertake a variety of adaptation measures and meet the costs themselves. One resident showed us the metal gabion in his backyard that he has filled with various kinds of rubbish (gasoline drums, bottles, rocks, etc) in order to protect his house. Planting trees along the shoreline is considered to be another viable option to protect the coast and stem coastal erosion. Fifteen per cent of residents planted trees as an adaptation measure: for example, "I planted coconut trees near the shoreline to hold the soil" and "We (and the neighbours) planted trees along the beach to hold the soil." Another said, "We had to remove the kitchen and plant strong, special trees near the coastline." Currently, the state, with funding from the USA, is helping residents to buy seedlings for replanting.

Only two respondents said they had moved to higher ground. This does not mean that moving to uphill areas has not been used as an adaptation measure but is most likely the result of our sampling method. The household questionnaire sample was administered to those

living along the first 60 metres of the coast; therefore, the sample may not have captured those households who have already moved uphill. As a solution to the problem of coastal erosion, moving uphill was, however, mentioned by 7% of respondents.

4.3 Loss and damage to housing and properties

The previous section has shown that the majority of respondents affected by coastal erosion carried out adaptation measures. Yet, 92% of those who had carried out adaptation measures indicated that these measures were insufficient (see Figure 6). Household adaptation measures (seawalls, gabions, tree planting and landfilling) were limited by ecological physical limits, economic limits, and technical limits of adaptation. They are often only temporarily effective and protect only the segment of coastline behind the structure. If one household along the coastline builds a seawall but the neighbours fail to do so, the seawall will only have a limited effect. This limitation is thus not only physical and financial but also social. The island is very remote and the material used often inadequate to build adequate protection. The majority of households (56%) felt that the most effective solution to coastal erosion would be large-scale seawalls supported by the state as well as communal action in the form of landfilling (11%), moving to higher ground (7%) and planting trees (6%). Yet building seawalls, both autonomous as well as planned, requires large-scale financial inputs that cannot easily be met by residents or their governments.

Household adaptation measures, such as seawalls, gabions, tree planting and landfilling, are constrained by physical, economic and technical limits

In line with these findings, survey respondents who did not carry out any adaptation measures at household level indicated that this was mostly due to lack of financial means (71%), lack of the necessary knowledge (41%) or skills (40%), or lack of other resources (18%) (see Figure 6) According to one respondent, "It is not very easy to think of a solution or anything that could deal with the impact."[12] Our data clearly revealed that lack of the necessary knowledge on materials to use and the lack of technical capacity to know how to build adequate adaptation measures was a significant limitation in carrying out adaptation measures. Coastal erosion is perceived to be a very serious threat by many on the island, and only 3% of the affected respondents did not adopt any adaptation measures because they did not consider it a priority.

Non-adaptation resulted from lack of money, knowledge, skills or other resources. In only 3% of the households, adaptation was 'not a priority'

[12]Lucy Killin, female, 69, Utwe, 21 July 2012

At state level there are also limitations to adaptation. The state has acknowledged the increasing negative impacts of climate change and various recent policy documents highlight this, most notably the Nationwide Climate Change Policy (NCCP) in 2009, the National Energy Policy and State Action Plans (NEP) in 2010, the National Action Plan to Combat Land Degradation (NAP) in 2011, and the UNFCCC FSM National Communication (2012). The state has declared policies to reduce the human causes of coastal erosion, such as the prohibition of sand mining and climate change awareness programmes. The Climate Change Bill passed by the state of Kosrae requires that all new initiatives or developments on the island must be climate proof (eg when a new road is built it has to be at a higher elevation to withstand sea level rise).[13] However, the Bill has not been implemented due to lack of material and financial resources, and is being incorporated into the Environmental Impact Assessment regulations currently being formulated.

Adaptation measures provide only temporary relief and some have negative side-effects

Adaptation measures can also cause other environmental problems (Eriksen et al., 2010). The autonomous adaptation measures residents have carried out provide only temporary relief at best. Gabions filled with paint drums and other waste can cause environmental hazards. Planned sea walls have also had unforeseen and undesired environmental consequences. They have caused changes in currents and beach loss, and caused coastal erosion at the edges of the wall (Maharaj, 1998). Data from our in-depth interviews and focus group discussions shows that, in most cases, planned sea walls resulted in intensified erosion at the edges of the construction and caused changes in currents. This is in line with the findings by NIWA (2013). NIWA also describes the *develop-defend-develop cycle*. This process involves residents living in vulnerable locations. After a storm or other extreme event, either residents feel the need to protect themselves or the state wants to protect its residents. After the defence has been erected people feel more secure and 'protected' leading to even further development. When a new storm occurs, and/or the coastal defence breaks down, there is even larger demand for better or larger coastal defences.

The study also found social and cultural constraints to adaptation, such as resistance to move to higher ground

Limits to adaptation were also found in endogenous factors including social and cultural limiting factors (Adger et al., 2009). These limitations on Kosrae can, for instance, be found in relocation to higher grounds and the cultural practice of burying loved ones close to their house, and thus often by the sea. Low-lying reef islands in the Pacific Ocean are perceived to be

[13] See e.g. http://www.kpress.info/index.php/climate-change/576-kosrae-pacc-a-shining-example-of-climate-change-adaptation-measures

particularly vulnerable to the impacts of sea-level rise. On a number of low-lying atoll islands there are no uphill areas to which residents can move. Kosrae has steep, uphill areas but only two respondents had moved to higher grounds. This does not necessarily mean that moving to uphill areas has not been used as an adaptation measure, but results partly from our sampling method. We interviewed all households living within 60 metres of the coastline. However, when asked about solutions to coastal erosion, 'moving uphill' was only mentioned by 7% of respondents. Not only is access to the area difficult, it also lacks access to drinking water, electricity and telecommunications. Not all residents have land in uphill areas. Those who do will have to invest in building new homes and relocating. Those who do not have land in uphill areas will depend on the state to give them land. As most land is privately owned, the state would have to buy land from private owners before it can redistribute it. Furthermore, land distribution could change social relations and create potential conflict. Residents would also have to change their culture of living very close to the sea with a culture of living in the higher, elevated and hilly areas.

Box 4.6: *"We bury our loved ones right next to our house. We want to have our loved ones close to us. But now sea-level rise and floods cause problems with the burial of our loved ones while we want our loved ones to rest in peace. We can't go on burying them like this and maybe we have to think of other ways to bury them."*
(Alik Sigrah, male, 67, Lelu, 24 July 2012)

Coastal erosion is also affecting burial culture on Kosrae. In Micronesian culture, burial plays a major role (Spennemann, 2006). While burial patterns have changed with the arrival of Christianity, the land claims derived from burials remain strong (Spennemann, 2006). Many loved ones are still buried next to present day houses and family property. As most residents live right along the coastline, these graves are often close to the sea. With increasing loss of beach front, traditional burial practices are now being threatened.

Grave next to the sea in Kosrae. Photo: Carlos Cianchini

Remnants of the Lelu ruins. Photo: Iris Monnereau

On Lelu island, resources to build seawalls and fill land are particularly limited as there are no large hills and rocks. In former times it was used as the residence of chiefs, while the main island Kosrae was for commoners. In the six centuries before European contact, the people erected an island city on Lelu island consisting of more than 100 compounds, paved roads and buildings with walls up to seven metres high (Morgan, 1988). Residents have used the basalt rocks from their ancient heritage site to build seawalls. Although it is presently illegal to use the ancient stones, residents commented on the loss of cultural heritage.

Box 4.7: "The sea keeps on rising and the people need to protect themselves. They have used the stones from the ancient ruins on Lelu Island to build walls and fill the land. For centuries the commoners built a complete city for the chiefs with paved roads and large houses made of rocks coming from Kosrae. Huge rocks, weighing tonnes, had to be shipped from the main island of Kosrae to Lelu island by wooden canoe over the open ocean. Now, when I visit the ruins most of the walls that used to be there when I was young have disappeared." (Masayuki Skilling, male, 67 years, Lelu, 27 July 2012)

Chapter 5: Loss and damage from extreme weather events

5.1 Extreme weather event impacts

Seasonal sea levels are significantly lower during El Niño conditions and higher during La Niña conditions (± 15 cm). Over a year, tide levels on Kosrae tend to be higher between November and February. Over the past years there have been high solstitial tides with seasonal water levels during October to February in La Niña years (ABM and CSIRO, 2011: 65). It was beyond the scope of this study to establish a link between increased flooding and high king tides and climate change. Doug Ramsey of the National Institute of Water and Atmospheric Research in New Zealand (Personal communication; NIWA, 2013) argues increased flooding is purely the result of La Niña phenomena over the past decade and not a result of climate change. Kosrae is out of the natural hurricane range in the southwest Pacific, but the impacts of hurricanes in the region are directly felt in Kosrae. In both the Indian and southwest Pacific Oceans, a significant increase in the number and proportion of hurricanes reaching categories 4 and 5 has been observed over the past 35 years (Webster et al., 2005; Hay and Mimura, 2006). Kosrae is also located in one of the areas where NASA has shown sea-level rise to be most extreme (NASA, 2008). Increased impacts on Kosrae can therefore be expected.

We have examined the perceptions of residents in relation to extreme high tides, known as 'king tides' (not to be confused with daily high and low tides) and the coping measures they have carried out. These tides mostly occur as a combination of a severe storm with a very high tide (eg as a result of the season and moon) and solstitial tides [14] mostly from October to February. These events occur on Kosrae in combination with a period of La Niña years, when there is significantly higher seasonal sea level water. The surveys showed that 62% of the households have experienced such an extreme king tides (see Figure 7).

King tides cause flooding of the coastal zone, resulting in loss and damage to housing, crops and economic trees, and damage to other assets. Respondents first answered a number of open-ended questions regarding their experience of extreme weather events, then answered closed questions about how the event affected their livelihood and the estimated monetary value of any damage. Respondents reported that the king tides affected them profoundly, saying, for example: "The water got into the house, flooded the floor, broke the walls and continued its way into the road"[15], "Our roof was blown away and we had to gather our belongings and move to the higher ground until the wind settled."[16]

Figure 7 shows the impact of extreme weather events on the households surveyed. Of those who had been affected, 80% suffered moderately from the event, while 20% suffered severe impacts. The map (Figure 8) clearly shows that the villages of Tafunsak and Malem are most vulnerable to extreme weather events, most likely due to wind

[14] Solstitial tides are an effect of the astronomical event when the sun's relative position to the sun changes

[15] Joshua Albert, male, 46, Tafunsak, 24 July 2012

[16] Nena Abraham, female, 59, Lelu, 23 July 2012.

direction and lack of shoreline protection. The latter is due to a lack of mangroves in these areas (see Figure 9) and to the intense reef dredging and sand mining that has taken place in Tafunsak.

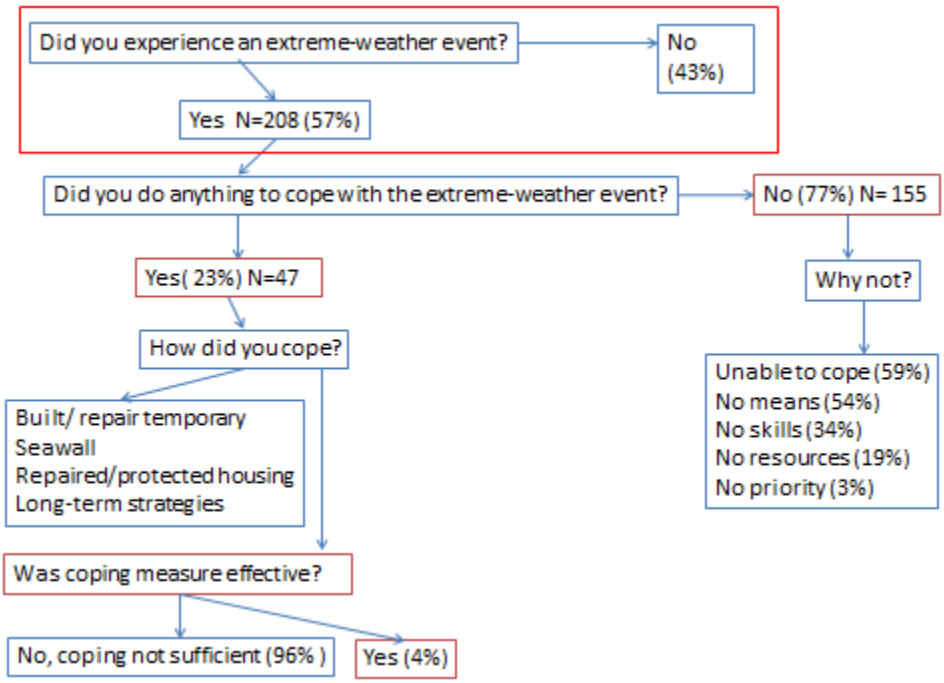


Figure 7: Experience of extreme weather event on Kosrae

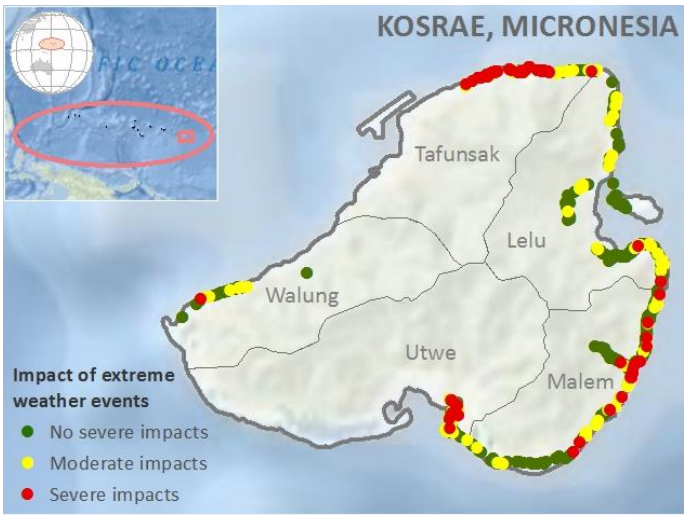


Figure 8 Map of Kosrae showing the households indicating they have suffered from an extreme-weather event.

Figure 9: Map of mangroves vegtation on the coast of Kosrae.

King tides can cause inundation and damage to housing, and can wash away outside built kitchens and livestock. Alokoa Jonithan and his wife, both from Tafunsak, recall what happened to their household in December 2008 when the storm hit their house (see Box 5.1).

The house of Alokoa Jonithan (taken from a tilted position), during the 2008 extreme event (box 5.2 and 5.4). Photo: Carlos Cianchini

Alokoa Jonithan, his wife and grandson in front of the house, July 2012 (box 5.2 and 5.4). Photo: Iris Monnereau

Box 5.1: "The storm came and broke the door and smashed the windows. The shoreline behind our house had already completely disappeared because of coastal erosion, so now the seawater quickly filled the house. Everything inside the house got wet – mattresses, clothes, and furniture. The kitchen next to the house, built of bamboo and thatch, completely washed away. The only thing left was the cement floor. Our three dogs were washed away and disappeared in the dark. Water also entered the pigpen, but fortunately, the pigs survived. We had to stay with family for ten months while we rebuilt our home. We are building a new house in the hills, however, because the seawall and gabions we have built ourselves are no longer protecting us. The gabion nets are rusting and the waves are breaking down the seawall. The sea is almost reaching our house. Our grandson will not be able to grow old in this house. (Alokoa Jonithan, 55 years, male, Tafunsak).

Line Mitcher, a 73-year old widow, recalls how she experienced the terrrifying moments of the 2008 storm surge (see Box 5.2).

Box 5.2: "In 2008 we experienced a king tide. All of a sudden we noticed a few waves starting coming strong towards our cooking house and pounding against the main house. A big surge followed and came right inside our sleeping house and the cooking house. It destroyed our cooking house and washed out our cooking supplies. I saw my washing machine floating away. I was so terrified that day, I could not believe what had happened." (Line Mitcher, female, 73 years, Tafunsak, 30 July 2012)

Line Mitcher in front of her affected house (box 5.2). Photo: Simpson Abraham

Example of the impact of the 2008 floods Photo: Carlos Cianchini. Photo: Carlos Cianchini

Respondents recalled 17 different years when they discussed the extreme weather event that had affected them between 1980 and 2012. Yet, when asked the year of the extreme weather event that caused them most damage, the six main events were between 2000 and 2011. The two years in which most residents affected were 2008 and 2011 (see Table 5.1). Of the 363 respondents, 208 had experienced an extreme weather event.

Box 5.3: "In December 2008 we were inside our house when the first storm came. Our house is made of concrete so at first we weren't scared. Than the storm broke all the windows and the door broke. The broken door disappeared in the waves. It scared us as the waves now were coming inside our house. The house quickly flooded and everything got wet – our clothes, our furniture, the mattresses on the floor. Our cooking area is outside and the storm took the whole kitchen away. All the pots and pans disappeared in the dark. As the storm got worse, and more and more water came in, the house turned into a swimming pool. We had to find refuge at my mom's house up in the hills." (Sepe Santos, female, 63, Tafunsak, 17 July 2012)

As shown in Table 5.1, the island was most affected by the extreme weather event of 2008. Towards the end of December that year, a major king tide flooded a large part of (mostly) the northern side of island. On 24 December, the governor of Kosrae, Robert Weichbacher, declared a state of emergency because of the damage the king tide had caused through flooding and the destruction of community, government and business structures. Thirty businesses were severely affected and also 31 households (15 of which sustained major damage), according to a damage survey carried out by PDA (2009). Even more importantly, roughly 30% of the land in the three main areas hit by the king tide was affected by saltwater intrusion. Many crops were lost or damaged – eg 80% of the bananas, 65% of the taro and 65-70% of breadfruit, the main household food staples farmed by householders (PDA, 2009).

Year	% (N= 208)	N
2000	7	14
2003	5	10
2004	13	26
2008	32	67
2010	5	10
2011	26	55

Table 5.1: The six years of most extreme weather events, as noted by respondents

There were no casualties among the 208 respondents affected by the extreme weather event, although around ten respondents or their household members had had minor injuries such as cuts to legs and arms and skin infections due to the high water. However, households did suffer damage to their housing (50%), economic trees (46%), crops (43%), fishing (11%) and livestock (7%). The most damage was to pigs, which either drowned or their pens were flooded. Fishing was impacted, as the number of fish had declined because of the storm and it was too dangerous to go out fishing during the storm.

Pig pen flooded during the 2008 king tide. Photo: Carlos Cianchini

N	Damage category	Average damage per affected hh (US$)	Total damage per category (US$)
59	House	3,679	217,061
40	Furniture/kitchen supplies, etc	2,025	81,000
25	Income lost	1,594	39,850
38	Clean-up	396	15,048
5	Vehicles	1,600	8,000
20	Other	321	6,420

Table 5.2: Damages resulting from the extreme event, in US$ (categories are not exclusive)

Of the 208 respondents who had suffered from an extreme weather event, 50% experienced loss and damage to their housing. Of these, 51% indicated

the impacts were moderate, whereas 49% said they were severe. Respondents mostly indicated their houses had been (partly) destroyed and flooded. Often their outside kitchens had disappeared and roofs were blown off (see Table 5.2). Table 5.2 shows householders' monetary losses. The damages were estimated by 71 households. Table 5.2 clearly shows that most damages was to houses and furniture (including mattresses, tables, beds, chairs, ovens, pots and pans, kitchen supplies, etc), followed by loss of income, clean-up and vehicles

.

Box 5.4: "We had nowhere to cook and the inside of the house had to be redone completely. The Red Cross gave us new pots and pans and plastic containers. Our house took a long time to rebuild. During the day we would have a tent close to our house where we would cook but it took ten months before we could move back. We are building a new house in the hills, as the seawall we have built ourselves is not protecting us. We put rocks in metal nets, called gabions, and put them here behind our house to protect us from the sea but the nets are rusting. The waves are breaking down the stone walls in place. We have started building seawalls while waiting for monetary assistance. The sea almost reaches our house. Our grandson will not be able to grow old in this house so we are building another house in the hills. We will need to start a new life over there. We are lucky we have land there as many families do not have land in the hills." (Alokoa Jonithan, male, 55 years, Tafunsak, 17 July 2012)

5.2 Coping with extreme-weather events

The majority of respondents (75%) who had suffered from an extreme weather event did not adopt any short-term coping measures to deal with the impacts. For the 25% who did, the main coping strategies were temporary repair of seawalls, putting up rubbish, rocks or bags of cement to stop water from intruding, and repairing houses to stand the storm. Many respondents, however, referred to more long-term coping – that is, adaptation rather than coping – building seawalls or gabions or planting trees. Of those who carried out coping measures, 96% indicated this was not enough and that "The area is still experiencing water intrusions. The waves still go over the seawalls",[17] and "When there are strong, high tides the sea walls are no use. It reduces the impact, though, but there are still water coming in".[18]

5. 3 Loss and damage

As noted in Chapter 1, loss and damage refers to "*adverse effects of climate variability and climate change that people have not been able to cope with or adapt to".* Figure 7 shows that the majority of households (57%) have suffered from extreme weather events. Of these households, 25% had adopted coping measures. Yet, of the

[17] Joshua Albert, male, 46, Tafunsak, 24 July 2012

[18] Marcilyn Nulud, female, 38 years, Malem, 13-07-2012

respondents who had attempted to cope with the extreme event, 96% still suffered from the impacts, as their coping measures were not sufficient to deal with the rising sea level and increased frequency of storms.

Sepe Santos in her kitchen/store and the house that was destroyed (box 5.3). Photo: Iris Monnereau

The destroyed house of Sepe Santos (box 5.3). Photo: Iris Monnereau

As Sepe Santos from Tafunsak tells us, "We love this place right here by the sea. But we know we will have to move to higher ground in the future. There used to be so much beach in front of our house. Now I don't feel good when I see the beach in front of my house. Only when it is low tide we have beach now." (Female, 50 years, Tafunsak, 17 July 2012)

Of those who did not carry out any coping measures, which was the majority (77%) of those who suffered from an extreme event, this was mostly due to inability to cope (59%) or lack of means (54%) or skills (34%) (more than one answer was possible). Only 3% did not carry out coping measures because the problem was not a priority for them. Damage to housing led to temporary migration for 26% of those who experienced from an extreme-weather event. They mostly stayed with family who live on higher ground. A few had to live somewhere else for up to a year while they rebuilt their house, yet, most residents (96%) could return to their homes within two weeks.

The impacts of extreme weather events reinforce the cycle of coastal erosion by breaking down protection such as seawalls, gabions and land filling. Houses are damaged and agricultural land becomes unsuitable. As crops and (commercial) trees die, as respondents indicated, there are no roots and plants to keep the soil together and coastal erosion is intensified. Loss and damage from king tides is thus very much related to the loss and damage caused by long-term coastal erosion.

Chapter 6: Discussion and conclusion

6.1 Summary

This study has demonstrated that households perceive high levels of coastal erosion, a finding in line with other reports indicating significant coastal erosion on Kosrae (Development Review Commission, 2000; Fletcher and Richmond, 2010). Kosrae has experienced significant levels of coastal erosion over the past decades, threatening communities and vital infrastructure in the most vulnerable low-lying areas. The majority of respondents (87%) have been affected by coastal erosion over the past two decades. The coastline has retreated, beaches have disappeared, and coastal roads are at risk of being washed away. As a consequence, 80% indicated their household economies have been affected – mostly crops, trees and housing. Respondents also suffered from a loss in culture.

The majority of respondents (87%) have been affected by coastal erosion over the past two decades.

Of those households who were affected by coastal erosion, 60% have carried out adaptation measures. They have tried to adapt by building seawalls, reinforcing their homes, and planting trees. The adaptation measures have mostly been autonomous and implemented at household level, although some community and government-planned seawalls have been built, although on a small scale. Adaptation measures were both reactive and anticipatory, as the measures that households adopted were in response to current and past experiences of coastal erosion and flooding as well as the expected threats of the future.

60% of affected households took measures to adaptation, such as building seawalls and planting trees along the coastline

This study has shown that despite adaptation measures, households still experience residual loss and damage; 92% of respondents still suffered from negative effects of climate change and were unable to counter the effects of coastal erosion. The ability to carry out adaptation measures was often curtailed by material, technical and financial limitations. The majority of those who did not carry out adaptation strategies indicated this was due to lack of resources, skills or knowledge.

For 92% of the 'adapting households' the measures were not enough to avoid loss and damage

In addition to gradual changes, 57% of the surveyed households have also suffered adverse effects of extreme weather events, in this case 'king tides'. These events have had short-term (eg damage to housing) and long-term impacts (eg severe damage to housing, salinization of agricultural land and economic trees) on

households. The loss of land and protecting plants and trees along the shoreline further intensifies the problems. Of those who experienced these extreme events, only 25% had carried out coping mechanisms, yet 96% said the measures were insufficient. The main coping mechanisms were building or repairing temporary seawalls and repairing houses; some longer-term coping measures were also undertaken. Those who did not carry out coping measures indicated this was mainly due to an inability to cope, lack of means or lack of skills. Only 3% did not prioritise coping mechanisms. As the impacts of climate change are expected to worsen in the region, the vulnerability of Kosrae residents to coastal erosion can be expected to increase as well. Support to counter coastal erosion on Kosrae, FSM, is therefore of great importance.

6.2 Reflections

In this study we have examined the impacts of coastal erosion on Kosrae, the various adaptation measures carried out by households and the limitations thereof. Studies suggest that rising sea levels, particularly in the Pacific Ocean, can lead to a reduction in island size. Coastal erosion is one of the most prominent concerns on Kosrae (Mimura, 1999; Fletcher and Richmond, 2010). This study has demonstrated that, in line with other reports, a large percentage of households in the survey have experienced coastal erosion. The coastline has retreated, beaches have disappeared, and coastal roads and other infrastructure are at risk of being washed away. For the large majority, this affects their household, for example with impacts on housing or crop cultivation. Of those households impacted, 60% had carried out autonomous adaptation measures such as building seawalls, reinforcing their homes, and planting trees.

The coastline has retreated, beaches have disappeared, and coastal roads are at risk of being washed away.

Over half of the households interviewed suffered from extreme weather events. These reinforced the cycle of coastal erosion and coping strategies thus consisted of both long-term and short-term strategies. Long-term strategies overlap with adaptation strategies, such as building and reinforcing seawalls and gabions, repairing housing, landfilling and planting trees. In line with Adger and colleagues (2007), and Füssel (2007), our findings show that the theoretical distinction between reactive and proactive adaptation measures is fuzzy in reality. Household decisions to undertake adaptation measures were often triggered by an extreme weather event, but were largely made in anticipation of future risk changes.

Our findings show that the theoretical distinction between reactive and proactive adaptation is fuzzy in reality

Adaptation measures on Kosrae illustrate the resilience of people and their aspiration to protect their housing and culture. As the island is very

remote, residents have used rocks, coral and sand to build seawalls and have filled gabions with whatever material they could find. This study argues that the adaptation measures adopted by most households are only partly successful in avoiding adverse effects of coastal erosion and that there are limits to adaptation. This study reveals that the limits faced by households to adaptation have physical, economic and technical dimensions as well as social and cultural aspects (Adger et al., 2007, 2009, 2013). The ability of an individual household to build a seawall and halt coastal erosion is limited both by their financial means, the physical limitations of small seawalls constructed by one household but perhaps not by his or her neighbours, and the lack of technical material and knowledge to build adequate adaptation measures.

adaptation measures are only partly successful in avoiding adverse effects of coastal erosion; there are limits to adaptation

In addition to the autonomous adaptation measures at household level, several planned adaptation measures have been carried out. These mostly relate to the state-funded building of seawalls. These have been only partly effective and often caused further coastal erosion in other locations. The seawalls were effective at reducing the impact of coastal erosion where the seawall was situated, but created negative environmental consequences at its outer edges. Building more, and/or, improper seawalls could negatively affect the coral reefs around the island, affecting both biodiversity and fishing activities.

The study also found social and cultural adaptation limits and constraints

Outside of these more exogenous limits to adaptation we also found a number of more endogenous limits that relate to social and cultural factors (Adger et al., 2009). Relocation to uphill areas comes with social consequences and limitations, as it would affect current land tenure systems. Traditionally, nearly all infrastructure and population are located in the narrow strip bordering the sea. As communities move uphill, new infrastructure and basic facilities will be needed in those areas. Cultural changes will also result from people's move away from the sea. Kosraeans are also accustomed to living close to where their loved ones are buried, and increased coastal erosion is affecting burial practices. The loss of culture as people have to change burial practices and the ongoing loss of land and homes have far-reaching consequences that cannot be reversed, and adaptation measures need to incorporate these cultural values.

This study showed that measures households adopted to deal with impacts of coastal erosion are not enough to avoid loss and damage due to limits in household adaptive capacity. As a consequence, these measures have economic, social, and cultural costs that are not regained. Despite adaptation measures, households still incur residual loss and damage; 92% of

respondents still suffered from negative effects of coastal erosion and were unable to counter its effects. In the working definition used in this study, loss and damage refers to the negative effects of extreme weather events and slow-onset climatic changes that people have not been able to cope with or adapt to (Warner et al., 2012: 20).

loss and damage goes beyond material losses and touches on people's culture and identity

This research links loss and damage explicitly with the literature about limits to adaptation and non-economic losses (Adger et al., 2005, 2007; Warner et al., 2013). We have seen loss and damage that goes beyond material losses and touches on people's culture and identity values which contribute to the functioning of society as a whole. Implementation of new adaptation strategies requires significant institutional and political reform, technical support, social changes and financial support from donors. In order to improve future adaptation measures, collective collaboration and planned adaptation measures are necessary, for example relocation and advanced technological coastal defences adapted to local circumstances. These adaptation measures, however, need to be sustainable (Eriksen et al., 2010) and contribute to socially and environmentally sustainable development pathways.

6.3 Significance of findings

This case study can serve as an example of similar challenges faced by many other islands and the limitations and constraints SIDS face in dealing with climate change. Although Kosrae is an island that, in comparison with low-lying atolls in the Pacific Island region, has a larger area of uphill areas, it nevertheless faces similar challenges. This study is an example of limits to adaptation and the loss and damage that other islands in the region will face equally, if not more so. Kosrae's vulnerability is characterised by: predicted severe impacts of climate change, sea-level rise and extreme events; its relative isolation; the concentration of population, socio-economic activities and infrastructure along the low-lying coastal zone; and its insufficient financial, technical and institutional capacities. This extreme vulnerability seriously limits the capacity of Kosrae, and SIDS in general, to adapt to adverse impacts of climate change.

Enhancing adaptive capacity is critical to meet the challenges of climate change and sea-level rise

Enhancing adaptive capacity is thus critical for SIDS if they are to meet the challenges of projected climate change and sea-level rise. Yet, climate change is just one of the pressing problems that most SIDS face. Other socio-economic concerns, such as poverty alleviation, high unemployment, improving housing and education, all compete for scant resources. Adaptation measures must therefore be framed within the larger development goals of SIDS.

Coastal erosion has severely impacted the livelihoods, housing and culture of the residents of Kosrae, both as a result of ongoing climate changes as well as other natural factors and human activity over the past 50 years. Dredging of the reef flat, sand mining, cutting trees and mangroves and altering river outlets have all had a profound impact on current beach retreat. At the same time, current climate change has been exacerbating this vulnerability as it has become clear that sea-level rise is more than average in the FSM in comparison to surrounding areas in the Pacific Ocean and residents indicate that the impacts of extreme weather events over the past few years have been the worst of the last 20 years. Increasing coastal erosion will also enforce this cycle – that is, the more trees lost to coastal erosion, mangroves and the protective reef, the greater the impact of coastal erosion. This study has shown that despite adaptation and coping measures, households still suffer from loss and damage. The limits to Kosrae's ability to implement adaptation measures are in line with the vulnerability of SIDS in general.

Chapter 7: Reflections for policymakers

The recommendations we propose below are based on the in-depth interviews, the open-ended questions regarding policies in the questionnaire, focus group discussions, the DRC report (2000) and the NIWA report (2013).

International donors are needed to support:

- improvements to the inner roads on the island to improve access for people living in uphill areas (the most appropriate roads to be enhanced are set out in NIWA, 2013)
- State and church awareness and outreach programmes on replanting and on harmful practices such as sand mining and mangrove destruction
- state purchases of land in uphill areas to help residents without land to move to uphill areas

Preventive measures should be taken by the state and by Kosrae housing agency so that all new development (eg houses, infrastructure):

- is located away from areas at risk from current and future coastal hazards
- is 'climate proofed' in design to incorporate weather and climate extremes (eg building roads at high elevations to withstand flooding in future)

The state should:

- continue to prohibit and enforce legislation on sand mining or coastal rubble removal by residents
- stop the breakdown of natural buffers by prohibiting the removal of vegetation behind beaches, landfilling, and reclaiming of mangrove areas
- maintain existing coastal defences
- limit new coastal defences and only build with permission

Awareness raising by KIRMA, KCSO and the church should help to:

- continue and enhance current replanting efforts
- build residents' knowledge on topics such as sand mining, coral rubble removal, the importance of mangrove areas and other beach protection areas, as well as inappropriate building of coastal defences
- relocate residents to uphill areas; this can be insured only by improving inner roads and prohibiting construction of new houses in low-lying areas.

References

Adger, N., Huq, S., Brown, K., Conway, D. and Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies* 3 (3), 179-95.

Adger, N., Arnell, N. and Tompkins, E. (2005). Successful adaptation to climate change across scales. *Global Environmental Change* 15, 77-86.

Adger, W.N., Agrawala S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit, B.and Takahashi, K. (2007). *Assessment of adaptation practices, options, constraints and capacity. Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds), Cambridge University Press, Cambridge, UK, 717-743.

Adger, N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D., Naess, L., Wolf, J. and Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climate Change* 93: 335-54.

Adger, N., Barnett, J., Brown, K., Marshall, N. and O'Brien, K. (2013). Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change* 3: 112-117.

Australian Bureau of Meteorology and CSIRO (2011). *Climate Change in the Pacific: scientific Assessment and new research*, Volume 1: Regional Overview, Volume 2: Country reports.

Barnett, J. and Adger, N. (2007). Climate change, human security and violent conflict. *Political Geography* 26 (6): 639-655

Bindoff, N.L., Willebrand, J., Artale, V., Cazenave, A., Gregory, J., Gulev, S., Hanawa, K., Le Quéré, C., Levitus, S., Nojiri, Y., Shum, C.K., Talley, L.D. and Unnikrishnan, A. (2007). Observations: Oceanic Climate Change and Sea Level. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)] Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2007.

Brooks, N., Adger, N. and Kelly, P. (2005) The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change* 15 (2): 151-163.

Burns, W. (2003). The impact of climate change on Pacific Island Developing countries in the 21st century. *Advances in Global Change Research*, 2003 2: 233-250

Coulthard, S. (2012). Can we be both resilient and well, and what choices do people have? Incorporating agency into the resilience debate from a fisheries perspective. *Ecology and Society* 17 (1): 4.

Dazé, A., Ambrose, K. and Ehrhart, C. (2009). *Climate Vulnerability and Capacity Analysis Handbook*. CARE International. http://www.careclimatechange.org.

Development Review Commission (DRC) (2000). *The Kosrae Shoreline Management Plan: Summary of Recommendations*. Kosrae.

Doughlas, C. (2006). Small island states and territories: sustainable development issues and strategies – challenges for changing islands in a changing world. *Sustainable Development* 15 (2): 75-80.

Dow, K., Berkhout, F., Preston, B., Klein, R., Midgley, G. and Shaw, M. (2013). Limits to adaptation. *Nature Climate Change* 3: 305-307.

Eakin, H. and Patt, A. (2011). Are adaptations studies effective, and what can enhance their practical input? *WIREs Climate Change* 2: 141-153.

Eriksen, S., Aldunce, P., Bahinipati, C.S., Martins, R.D'A., Molefe, J.I., Nhemachena, C., O'Brien, K., Olorunfemi, F., Park, J., Sygna, L. and Ulstrud, K. (2010). When not every response to climate change is a good one: identifying principles for sustainable adaptation. *Climate and Development,* 3(1): 7-20.

FAO 2012. The state of the world fisheries and aquaculture (SOFIA) 2012. Rome: FAO.

Fletcher, C. and Richmond, B. (2010). Climate Change in the Federated States of Micronesia. Food and water security, climate risk management, and adaptive strategies. University of Hawai'i, Hawaii.

Füssel, H. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change* 17: 155-167.

Hay, J. and Mimura, N. (2006). Supporting climate change vulnerability and adaptation assessments in the Asia-Pacific region: an example of sustainability science. *Sustain Sci* 1:23–35.

Kelman, I. (2010). Hearing local voices from Small Island Developing States for climate change. *Local Environment: The International Journal of Justice and Sustainability* 15 (7): 605-619.

Leary, N. (1999). 'A framework for benefit-cost analysis of adaptation to climate change and climate variability', *Mitigation and Adaptation Strategies for Global Change* 4: 307-18.

MacNeill, A., Graham N., Cinner J.., Dulvey N., Loring P., Jennings S., Polunin N., Fisk A. and McClanahan. T. (2010). Transitional states in marine fisheries: adapting to predicted climate change. *Phil. Trans. R. Soc. B*. 365: 3753-3763.

Maharaj, R. (1998). *Assessment of coastal erosion problems in the outer atoll islands of Pohnpei, Chuuk and Yap States, Federated States of Micronesia*. SOPAC Technical Report 268. South Pacific Applied Geoscience Commission (SOPAC), Suva, Fiji.

McClanahan, T., Castilla, J., White, A. and Defeo, O. (2009). Healing small-scale fisheries by facilitating complex socio-ecological systems. *Rev. Fish. Biol. Fish*. 19: 33-47.

Meehl, G.A., Stocker, T.F., Collins, W.D., Friedlingstein, P., Gaye, A.T., Gregory, J.M., Kitoh, A., Knutti, R., Murphy, J.M., Noda, A., Raper, S.C.B., Watterson, I.G., Weaver, A.J. and Zhao, Z.-C. (2007). Global climate projections. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L. (Eds), *Climate Change 2007: The physical science basis. contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge and New York.

Mercer, J., Kelman, I., Alfthan, B. and Kurvits, T. (2012). Ecosystem-based adaptation to climate change in Caribbean small island developing states: integrating local and external knowledge. *Sustainability* 2012, *4*: 1908-1932; doi:10.3390/su4081908

Meyssignac, B., Becker, M., Llovel, W. and Cazenave, A. (2012). An assessment of two-dimensional past sea level reconstructions over 1950–2009 based on tide-gauge data and different input sea level grids. *Surveys in Geophysics*. doi:10.1007/s10712-011-9171-x

Mimura, N., Nurse, L., McLean, R., Agard, J., Briguglio, L., Lefale, P., Payet, R. and Sem G. (2007). Small islands, in Parry, M.L., Canziani, O.F., Palutikof, J.P, van der Linden, P.J. and Henson, C.E. (Eds) *Climate Change 2007: Impacts, Adaptations and Vulnerability*, *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge Press, Cambridge, pp. 687-716.

Mimura, N. (1999). Vulnerability of island countries in the South Pacific to sea level rise and climate change. *Climate Research* 12: 137–143

Mimura, N. and Nunn, P. (1998). Trends of beach erosion and shoreline protection in rural Fiji. *Journal of Coastal Res* 14 (1): 37– 46.

Mirza, M. (2003). Climate change and extreme weather events: can developing countries adapt? *Climate Policy 3:* 233-248.

Morgan, W. (1988). *Prehistoric Architecture in Micronesia*. University Texas Press. Austin, Texas.

Morrissey, J. and Oliver-Smith, A. (2013). *Perspectives on non-economic loss and damage: Understanding values at risk from climate change.* Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

Moser, S. and Ekstrom, J. (2010). A framework to diagnose barriers to climate change adaptation. *PNAS* 107 (51): 22026-22031.

NASA, Jet Propulsion Laboratory (2008). Rising waters: new map pinpoints areas of sea-level increase. http://climate.nasa.gov/news/?FuseAction=ShowNews&NewsID=16

Nelson, D., Adger, N. and Brown, K. (2007). Adaptation to environmental change: contributions of a resilience framework. *Annu. Rev. Environ. Resour* 32: 395-419.

NIWA (National Institute of Water and Atmospheric Research) (2013, forthcoming) *Kosrae Shoreline Management Plan: Repositioning for Resilience*.

Nurse, L. and Moore, R. (2005). Adaptation to global climate change: an urgent requirement for small island developing states. *Review of European Community & International Environmental Law,* 14 (2): 100-107.

Nurse, L. (2011). The implications of global climate change for fisheries management in the Caribbean. *Climate and Development* 3 (3): 228-241.

Nurse, L., Sem, G., Hay, J.E., Suarez, A.G., Wong, P.P., Briguglio, L. and Ragoonaden, S. (2001). Small island states, in McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken D.J. and White, K.S. (Eds) *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, pp. 842-975.

PACC (Pacific Adaptation to Climate Change Project). 2011. National communication strategy. Unpublished.

PDA (2009). Preliminary Damage Assessment Kosrae: Infrastructure, Agriculture and Businesses. Kosrae: Unpublished.

Pelling, M. and Uitto, J.I. (2001). Small island developing states: natural disaster vulnerability and global change. *Environmental Hazards* 3, 2: 49-62.

Rosenzweig, C., Iglesias A., Yang X., Epstein P. and Chivian, E. (2001) Climate change and extreme weather events: Implications for food production, plant diseases, and pests. *NASA Publications.* Paper 24. http://digitalcommons.unl.edu/nasapub/24 Accessed 15 February 2013.

Smit, B. et al. (2001): Adaptation to climate change in the context of sustainable development and equity. In McCarthy, J.J., Canziani, O., Leary, N.A., Dokken, D.J. and White, K.S., editors, Climate change 2001: impacts, adaptation and vulnerability. IPCC Working Group II. Cambridge: Cambridge University Press, 877–912.

Smit, B. and Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 16: 282-92.

Spenneman, D. (2006). Skulls as curios, crania as science: some notes on the collection of skeletal material during the German colonial period. *Micronesian Journal of the Humanities and Social Sciences*. Vol 5 (1/2): 70-78.

Tompkins, E. and Adger, N. (2005) Defining response capacity to enhance climate change policy. *Environmental Science and Policy* 8 (6): 562-571.

United Nations Statistical Division (2010) Environment Statistics Country Snapshot: Federated States of Micronesia http://unstats.un.org/unsd/environment/envpdf/Country_Snapshots_Aug%202011/Micronesia,%20Federated%20States%20of.pdf. Accessed September 13 2012.

United Nations Framework Convention on Climate Change (UNFCCC) (2005). *Climate Change, Small Island Developing States*. Issued by the Climate Change Secretariat, UNFCCC, Bonn, Germany.

Van der Geest, K. and T. Dietz. (2004). A Literature Survey About Risk and Vulnerability in Drylands With a Focus on The Sahel. In: Dietz, A.J., Ruben, R., and Verhagen, A. (eds.) *The impact of climate change on drylands, with a focus on West Africa.* Dordrecht: Kluwer Academic Publishers, pp. 117-146.

Warner, K. and Zakieldeen, S. (2011). *Loss and Damage due to climate change: an overview of the UNFCCC Negotiations*. ECBI Background Papers, European Capacity Building Initiative. Oxford. http://www.eurocapacity.org/downloads/LossandDamage.pdf

Warner, K., van der Geest, K., Kreft, S., Huq, S., Harmeling, S., Kusters, K. and de Sherbinin, A. (2012). *Evidence from the frontlines of climate change: Loss and damage to communities despite coping and adaptation*. Loss and Damage in Vulnerable Countries Initiative. Report No. 9. Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

Warner, K., van der Geest, K. and Kreft, S. (2013). *Pushed to the limit: Evidence of climate change-related loss and damage when people face constraints and limits to adaptation*. Report No. 11. Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

Warner, K. and van der Geest, K. (2013). Loss and damage from climate change: Local-level evidence from nine vulnerable countries. *International Journal of Global Warming*, Vol. 5, No. 4, pp. 367-386.

Webb, A. (2012). GIZ Coastal Scoping Mission. Presentation SOPAC – Applied Geoscience & Technology Division, SPC. Available through PACC project. www.sprep.org

Webb, A. And Kench, P. 2010. The dynamic response of reef islands to sea-level rise: Evidence from multi-decadal analysis of island change in the Central Pacific. *Global and Planetary Change* 72 (3): 234-246.

Webster, P., Holland, G., Curry, J. and Chang, H. (2005). Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science* 309: 1844 – 1846.

Suggested reading

Ten peer-reviewed journal articles based on the loss and damage case studies have been published in a special issue of the International Journal of Global Warming (Open Access):

Bauer, K. (2013). Are preventive and coping measures enough to avoid loss and damage from flooding in Udayapur District, Nepal? *Int. J Global Warming*, Vol. 5, No. 4, pp. 433-451.

Brida, A.B., Owiyo, T. and Sokona, Y. (2013). Loss and damage from the double blow of flood and drought in Mozambique. *Int. J Global Warming*, Vol. 5, No. 4, pp. 514-531.

Haile, A.T., Wagesho, N. and Kusters, K. (2013). Loss and damage from flooding in the Gambela region, Ethiopia. *Int. J Global Warming*, Vol. 5, No. 4, pp. 483-497.

Kusters, K. and Wangdi, N. (2013). The costs of adaptation: changes in water availability and farmers' responses in Punakha district, Bhutan. *Int. J Global Warming,* Vol. 5, No. 4, pp. 387-399.

Monnereau, I. and Abraham, S. (2013). Limits to autonomous adaptation in response to coastal erosion in Kosrae, Micronesia. *Int. J Global Warming,* Vol. 5, No. 4, pp. 416-432.

Opondo, D. (2013). Erosive coping after the 2011 floods in Kenya. *Int. J Global Warming,* Vol. 5, No. 4, pp. 452-466.

Rabbani, G., Rahman, A. and Mainuddin, K. (2013). Salinity induced loss and damage to farming households in coastal Bangladesh. *Int. J Global Warming,* Vol. 5, No. 4, pp. 400-415.

Traore, S., Owiyo, T. and Sokona, Y. (2013). Dirty drought causing loss and damage in Northern Burkina Faso. *Int. J Global Warming*, Vol. 5, No. 4, pp. 498-513.

Warner, K. and van der Geest, K. (2013). Loss and damage from climate change: Local-level evidence from nine vulnerable countries. *Int. J Global Warming,* Vol. 5, No. 4, pp. 367-386.

Yaffa, S. (2013). Coping measures not enough to avoid loss and damage from drought in the North Bank Region of The Gambia. *Int. J Global Warming,* Vol. 5, No. 4, pp. 467-482.

Appendix A: Loss and Damage Case Study Questionnaire:

1. Questionnaire number:
2. Date of interview: _ _ / _ _ / _ _
3. Name of village or town:
4. Name of interviewer:
5. Date of data entry: _ _ / _ _ / _ _
6. Name of data entry officer:

Section 1: Respondent, household, livelihood and vulnerability

1.1 Respondent and household information

7. Name:_____
8. Birth year [YYYY][write age (YY) if easier]:_____
9. Sex: 1=Male | 2=Female
10. Relation to household head: 1=Household head | 2=Spouse | 3=Other, specify_____
11. Marital status: 1=Single | 2=Monogamous marriage| 3=Polygamous marriage |4='Consensual union' |5=Widowed |6=Separated/divorced |7=Other, specify _____
12. Number of children: Sons ____Daughters _____
13. Place of birth: 1=This village or town | 2=Elsewhere in the region | 3=Elsewhere in the country, specify region _____| 4=Abroad, specify country _____
14. Education level: _____
15. Ethnicity/mother tongue:_____
16. Religion: 1=Christian | 2=Muslim | 3=Buddhist | 4=Hindu | 5=Other, specify _____
17. Occupation (multiple options): 1=Farming | 2=Livestock raising | 3=Fishing | 4=Trading | 5=Salary work ('white collar'), specify _____ | 6=Other non-farm income, specify _____ | 7=Farm labour | 8=Other labour, specify _____ | 9=Housework | 10=Student | 11=Unemployed | 12=Other, specify _____

18. Household composition: Adult men (aged 18-65) ___ | Adult women (aged 18-65) ___ | Boys (<18) ___ | Girls (<18) ___ | Elderly men (>65) ___ | Elderly women (>65) ___
19. How many members of your household are involved in activities that provide food or income? __

1.2 Land and farm

20. Do you (or does your household) 'own' land? 1=Yes | 2=No
    a. If yes, for what do you use your land (multiple options)? 1=House | 2=Crop cultivation | 3=Livestock raising | 4=Renting out | 5=Fallowing | 6=Nothing | 7=Other, specify _____
    b. If yes, please estimate the total land size? Number _____ Unit _____
21. Do you farm? 1=Yes | 2=No (if no, go to next section)
22. What is the size of the land that you cultivate this year? Number _____ Unit _____
23. Do you own the land you farm? 1=Yes, all | 2=No, none | 3=Partly
    a. If 2 or 3, how do you get access to this land (multiple options)? 1=Renting | 2=Sharecropping | 3=Borrow | 4=Community land | 5=Other, specify _____
24. Is some of the land you farm irrigated? 1=Yes | 2=No
    a. If yes, how much? Number _____ Unit _____
25. Which crops did you cultivate last year? [in order of importance] (1) _____ (2) _____ (3) _____ (4) _____ (5) _____ (6) _____
26. Do you use animal traction or a tractor to cultivate your land? 1=Yes | 2=No
    a. If yes, do you own, hire or borrow these implements (multiple options)? 1=Own | 2=Hire | 3=Borrow | 4=Other, specify _____
27. Do you employ people to work on your land? 1=Yes | 2=No
    a. If yes, please estimate the total number of 'person days' per year _____
28. What is the main purpose of your crop production (choose one)? 1=Household consumption | 2=Sale | 3=Other, specify _____

29. How much of your crop production do you usually sell? 1=Everything | 2=More than half | 3=Approximately half | 4=Less than half | 5=Hardly anything| 6=Nothing
30. How much income did your household derive from crop sales in the last 12 months? _____
31. In the last 10 years, did your crop production… 1=Decrease a lot | 2=Decrease a little | 3=Remain the same | 4=Increase a little | 5=Increase a lot
    a. If decreased or increased, please indicate the cause(s):

1.3 Livestock, fishing and economic trees

32. Do you or other household members own livestock? Please indicate the number of (1) Cows ___ | (2) Donkeys ___ | (3) Goats and sheep ___ | (4) Pigs ___ | (5) Fowls ___ (5) Others, specify ___
    a. If yes, what is the main purpose of your livestock (choose one)? 1=Household consumption | 2=Sale | 3=Traction | 4=Other, specify _____
    b. Please estimate the income you derived from livestock raising in the last 12 months? _____
33. Do you or any other household members engage in fishing or fish raising? 1=Yes | 2=No
    a. If yes, please specify: 1=Fishing | 2=Fish raising | 3=Both
    b. What is the main purpose of your fishing / fish raising (choose one)? 1=Household consumption | 2=Sale | 3=Other, specify _____
    c. Please estimate the income your household derived from fishing / fish raising in the last 12 months? _____
34. Does your household own economic trees (fruit, timber, etc)? 1=Yes | 2=No
    a. If yes, what is the main purpose of your economic trees (choose one)? 1=Household consumption | 2=Sale | 3=Other, specify _____
    b. Please indicate the number of economic trees:(1) <10 | (2) 10-50 | (3) 50-100 | (4) >100
    c. Please estimate the income your household got from economic trees in the last 12 months___

1.4 Other income generating activities

35. Do you or any household members derive income from non-farm activities? 1=Yes | 2=No
    a. If yes, how many household members engage in such activities? _____
    b. In which activities do they engage (multiple options)? 1=Petty trading | 2=Larger business | 3='White collar' salary work, specify _____ | 4='Blue collar' salary work, specify_____ | 5=Crafts, specify _____6=Processing natural resources, specify_____ 7=Other non-farm income, specify _____
    c. Please estimate the total income derived from non-farm activities in last 12 months? _____
36. Does your household receive remittances from migrant relatives or friends? 1=Yes | 2=No
    a. If yes, from whom [relation to HH-H] (multiple options)? 1=Daughter | 2=Son | 3=Brother | 4=Sister | 5=Parents | 6=Other, specify _____
    b. Where do they live (multiple options)? 1=Within the region | 2=Other region, specify _____ | 3=Abroad, specify_____
    c. Please estimate the total amount of money you received in the last 12 months_____
    d. And the value of other things (food, goods) you received in the last 12 months _____
37. Do you or household members sometimes labour on other people's farms? 1=Yes | 2=No
    a. If yes, how many household members? _____
    b. Please estimate: the total number of 'person days' in the last 12 months _____
    c. Please estimate the total annual income derived in the last 12 months_____
38. Do you have any other sources of income besides the ones you mentioned? 1=Yes | 2=No
    a. If yes, please specify source _____
    b. Please specify the total annual income derived in the last 12 months ____
39. Please estimate the amount of money your household usually has to its disposal:

    Amount_____ Currency _____ per (time unit): week / month / year

40. Compared to other households in your village/town, would you say that your monthly income is (1) Less than most others | (2) Average | (3) More than most others

1.5 Housing and other assets

41. Do you 'own' the house you live in? 1=Yes | 2=No
42. Do you own any other houses? 1=Yes, specify how many _____ 2=No
43. Please indicate the building materials of the house you live in:
    a. Roof (multiple options): 1=Roofing tiles | 2=Iron sheets | 3=Concrete | 4=Natural materials, e.g. thatch or earth | 5=Other, specify_____
    b. Walls (multiple options): 1=Cement blocks/concrete| 2=Baked bricks | 3=Sun-dried bricks | 4=Wood | 5= Iron sheets | 6=Other natural materials, specify_____ 6=Other, specify ___
    c. Floor (multiple options): 1=Cement | 2=Earth | 3=Wood | 4=Other, specify _____
44. How many bedrooms does the house you live in have? _____
45. Compared to the other houses in your village/town, would you say that the house you live in is (1) Of better quality | (2) Average or | (3) Worse quality?
46. Does your house have electricity? 1=Yes | 2=No
47. What is the source of your drinking water (multiple options)? 1=Surface water | 2=Well | 3=Borehole/Pump | 4=Pipe | 5=Other, specify ____
48. Does your house have a private latrine or WC? 1=Yes | 2=No
49. Please indicate whether your household owns the following assets [and how many]: (a) TV __ (b) (Mobile) phone __ (c) Bicycle __ (d) Motorbike __ (e) Car __ (f) Fridge __ (g) Computer __

1.6 Food security

50. How many meals a day do adults in your household eat on a 'regular day'? _____
51. How many meals a day do children in your household eat on a 'regular day'? _____
52. In the past year, have there been months that you had to eat less? 1=Yes | 2=No

a. If yes, in which months did this happen (multiple options)? 1=Jan | 2=Feb | 3=Mar | 4=Apr | 5=May | 6=Jun | 7= Jul | 8=Aug | 9=Sep | 10=Oct | 11=Nov | 12=Dec

b. What was/were the cause(s) of this food shortage?

53. In the past ten years, has your household experienced any food shortages? 1=Yes | 2=No

a. If yes, in how many out of ten years?

b. What was/were usually the cause(s) of such shortages?

54. How much of the food your household consumes is bought (i.e. not produced by household itself)? 1=Everything | 2=More than half | 3=Approximately half | 4=Less than half | 5=Hardly anything | 6=Nothing

Section 2: Impact of and adaptation to slow onset climatic changes

55. In the past twenty years, how many years have you lived in this [district, area or province]? ____

2.1 Open questions

56. What changes have you experienced in coastal erosion in your village over the last twenty years?

57. How has this (changes in) coastal erosion affected your housing situation??

58. How does your household adapt to the impact of coastal erosion on your housing situation? (if nothing done, please explain why not)

59. If yes, do you feel that despite these measures your household still experiences negative effects from (changes in) coastal erosion (multiple options)? 1=No | 2=Yes, measures not enough |3=Yes, measures have costs/negative effects | 4=Yes, other reason, specify _____

a. Please explain:

60. If no, why not (multiple options)? 1=Don't know what to do | 2=Lack of financial resources (to do what?) | 3=Lack of skills/knowledge (to do what?) |4=Lack of other resources (to do what?) | 5=It's not a priority/not very important to us | 6=Not my task/responsibility | 7=Other, specify

a. Please explain

2.2 Closed questions: slow onset climatic changes (impact + adaptation)

61. Have you experienced (more/any changes in)coastal erosion over the past twenty years? 1=Yes, a lot | 2=Yes, but only a little | 3=About the same | 4=No, less than before | 5=Not existed at all
62. If 1 or 2, does this adversely affect (the economic situation of) your household? 1=Yes, a lot | 2=Yes, but only a little | 3=No, it doesn't affect us at all
63. If yes, how does it affect your household?
    a. Negative effect on crops: 1=None | 2=Moderate | 3=Severe | 4=Not applicable (NA)
       If 2 or 3, explain: _____
    b. Negative effect on livestock: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    c. Negative effect on fishing: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    d. Negative effect on tree crops: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    e. Negative effect on trade/business: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    f. Effect on food prices: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    g. Damage to house/properties: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____
    h. Other negative effects, specify _____1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain: _____

Questions about what households do/did to adapt to (impacts of) climatic changes:

64. Did you modify agricultural production/fishing to deal with coastal erosion?

1=No | 2=Yes, shift to other crops/livestock/fish, specify_____| 3=Shift from rain-fed to irrigated agriculture | 4=Modify production techniques/inputs, specify _____5=Other, specify_____

65. Did you engage (more) in non-farm activities to deal with coastal erosion?

    1=No | 2=Yes, switch to new economic activities, specify _____ | 3=More household members engaged in economic activities | 4=Expand existing non-farm activities | 5=Other, specify _____

66. Did you or household members migrate (more) to deal with coastal erosion? 1=No | 2=Yes, I migrated | 3=Yes, other household member(s) migrated | 4=Yes, whole household migrated

    a. If yes, for what periods? 1=Short-term (<6 months) | 2=Longer-term (>6 months)

    b. If yes, where to? 1=Within region | 2=Other region, specify _____ | 3=Abroad, specify ____

    c. Was migration destination rural or urban? 1=Rural | 2=Urban

67. Did you do anything else to deal with coastal erosion? 1=No | 2=Yes, specify _____

68. (Only ask if measures were taken): Are these things you did to deal with coastal erosion enough to avoid negative effects on the living standard and well-being of your household? 1=No, still severe negative effects | 2=No, still moderate negative effects | 3=Yes, it allows us to carry on | 4=Yes, it has even improved our situation

    a. Please explain:

Section 3: Impact of and coping with weather-related extreme events

3.1 Open questions

69. Choose a storm surge that affected your household (the most severe one or the most recent one). Please mention the year [_ _ _ _] and reconstruct what happened:

70. How did this storm surge affect housing?

71. Did your household do anything to deal with (the impact of) [storm surge] on [housing]? 1=Yes | 2=No (if no, skip next two questions)

72. If yes, what did you do?
73. If yes, do you feel that despite these measures your household still experienced negative effects from [storm surge] (multiple options)? 1=No | 2=Yes, measures are not enough |3=Yes, measures have costs/negative effects | 4=Yes, other reason
    a. Please explain:
74. If no, why not (multiple options)? 1=Didn't know what to do | 2=Lack of financial resources (to do what?) | 3=Lack of skills/knowledge (to do what?) | 4=Lack of other resources (to do what?) | 5=It's not a priority/not very important to us | 6=Not my task/responsibility | 7=Other, specify
    a. Please explain:
75. If no, what negative effects (loss, damage, costs) did your household experience from storm surge because no measures were taken?

3.2 Closed questions: extreme events (impact and coping)

76. Has your household (ever) been affected by a storm surge?
    1=No | 2=Yes, but not severely | 3=Yes, severely
77. How many times has your household been affected by a weather-related extreme event over the past 10 years?
78. Did your or any other household member suffer an injury or illness due to a storm surge? (specify by minor injuries and major injuries)
79. If yes, how does it affect your household (multiple options)?
    a. Negative effect on crops: 1=No | 2=Moderate | 3=Severe | 4=Not applicable (NA)
       If 2 or 3, explain/estimate costs: _____
    b. Negative effect on livestock: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain/estimate costs: _____
    c. Negative effect on fishing: 1=None | 2=Moderate | 3=Severe | 4=NA
       If 2 or 3, explain/estimate costs: _____

d. Negative effect on tree crops: 1=None | 2=Moderate | 3=Severe | 4=NA

   If 2 or 3, explain/estimate costs: _____

e. Negative effect on trade/business/tourism: 1=None | 2=Moderate | 3=Severe | 4=NA

   If 2 or 3, explain/estimate costs: _____

f. Effect on food prices: 1=None | 2=Moderate | 3=Severe | 4=NA

   If 2 or 3, explain/estimate costs: _____

g. Damage to house/properties: 1=None | 2=Moderate | 3=Severe | 4=NA

   If 2 or 3, explain/estimate costs: _____

h. Other negative effects, specify _____1=None | 2=Moderate | 3=Severe | 4=NA

   If 2 or 3, explain/estimate costs: _____

80. If your housing was affected by the event were you forced to live somewhere else (due to the damage, repairs, and cleaning up)? 1= Yes/ 2= No

81. For how many days?

82. Was the house flooded? 1= Yes/ 2= No

83. Did the extreme event cause structural damage to your house?

84. If yes, estimate the amount of damage caused (in US$):

    Building:
    Contents:
    Vehicles:
    Lost income:
    Clean-up:
    Other:

Questions about what people did to cope with (impacts of) extreme events:

85. Did you ask for food or money from other people to deal with storm surge? 1=No | 2=Yes, from a relative | 3=Neighbour | 4=Friend | 5=Other, specify _____

86. Did you receive support from an organisation to deal with storm surge? 1=No |2=Yes, government agency, specify _____ | 2=NGO, specify_____ | 3=Religious organisation, specify _____ | Other, specify_____
87. Did you or household members try to earn extra income to deal with storm surge? 1=No | 2=Yes, intensified existing activities, specify_____ | 3=Engaged in new activities, specify_____
88. Did you or household members migrate (move) to deal with storm surge? 1=No | 2=Yes, I migrated | 3=Yes, other household member(s) migrated | 4=Yes, whole household migrated
    a. If yes, for what periods? 1=Short-term (<6 months) | 2=Longer-term (>6 months)
    b. If yes, where to? 1=Within Kosrae | 2=FSM, specify _____ | 3=Abroad, specify ____
    c. Was migration destination rural or urban? 1=Rural | 2=Urban
89. Did you sell capital to deal with storm surge? 1=No | 2=Yes, land | 3=Livestock | 4=House | 5=Productive assets, specify _____ 6=Means of transport, specify _____ | 7=Luxury items, specify _____ 8| Other, specify _____
90. Did you try to spend less money to deal with storm surge? 1=No | 2=Yes, spent less on food items | 2=On school fees | 3=On healthcare | 4=On productive investments, specify_____ | 5=On house maintenance | 6=Other, specify_____
91. Did you modify food consumption to deal with storm surge? 1=No | 2=Yes, bought less expensive foods | 3=Limit portion sizes | 4=Reduce number of meals per day |5=Adults ate less so children could eat | 6=Less people eating at home | 7=Other, specify_____
92. Did you do anything else to deal with storm surge? 1=No | 2=Yes, specify _____
93. If measures were taken, were these things you did to deal with coastal erosion enough to avoid negative effects on the living standard and well-being of your household? 1=No, still severe negative effects | 2=No, still moderate negative effects | 3=Yes, it allows us to carry on | 4=Yes, it has even improved our situation

a. Please explain:

4. Vulnerability, gender and policy

94. Do you feel that your household is more or less likely to suffer from the impacts of coastal erosion than other households in your community? 1=More | 2=Average | 3=Less
    a. Why?
95. Do you think that the impacts of these climate threats affect men and women differently? Please explain.
96. Do you think men and women play different roles in dealing with these climate threats? Please explain.
97. What are currently the biggest threats to your housing condition?
98. What do you think government agencies or other organisations could do to reduce the impacts of coastal erosion?
99. What should islanders do to reduce the impacts of coastal erosion/storm surges?
100. What would be your recommendations to help prepare for, prevent and protect your household from the impacts of sea-level rise?

Appendix B: List of in-depth interviews

Village	Date	Interviewer	Name of interviewee
Tafunsak	17-7-2012	Iris Monnereau	Sepe Santos
Tafunsak	17-7-2012	Iris Monnereau	Alokoa Jonithan
Lelu	20-7-2012	Iris Monnereau	Rooston Abraham
Lelu	18-7-2012	Iris Monnereau	Katrina Adams
Lelu	20-7-2012	Iris Monnereau	Josaiah Wagun / Senator
Leu	26-7-2012	Iris Monnereau	KCSO / Marston Weston Luckymis
Lelu	26-7-2012	Iris Monnereau	KCSO / Marston Weston Luckymis
Lelu	26-7-2012	Iris Monnereau	Ruthey Luckymis / KIRMA
Lelu	27-7-2012	Iris Monnereau	Masayuki Skilling
Lelu	24-7-2012	meeting	Alik Sigrah
Lelu	17-7-2012	Iris Monnereau	Ilai Abraham
Malem	18-7-2012	Iris Monnereau	Kilafwasru Kilafwasru
Utwe	18-7-2012	Iris Monnereau	Moses Alik
Lelu	30-7-2012	Simpson Abraham	Kiubu Luey
Lelu	31-7-2012	Simpson Abraham	Dorothy Edwin
Tafunsak	30-7-2012	Simpson Abraham	Line Mitcher

Appendix C: Focus group discussions

Focus group	Name of meeting	Date	Number of attendees
1	Policy and executive stakeholders	9 July 2012	27
2	Board of KIRMA[19]	19 July 2012	12
3	Senior citizens, Lelu	24 July 2012	18
4	Senior citizens, Malem	25 July 2012	15
5	Kosrae Senate	26 July 2012	11
6	Senior citizens, Utwe	31 July 2012	24

[19] KIRMA is a semi-autonomous government agency.

The Loss and Damage in Vulnerable Countries Initiative

Accepting the reality of unmitigated climate change, the UNFCCC negotiations have raised the profile of the issue of loss & damage to adverse climate impacts. At COP-16, Parties created a Work Programme on Loss and Damage under the Subsidiary Body on Implementation (SBI). The goal of this work programme is to increase awareness among delegates, assess the exposure of countries to loss and damage, explore a range of activities that may be appropriate to address loss and damage in vulnerable countries, and identify in which ways the UNFCCC process might help countries avoid and reduce loss and damage associated with climate change.

The "Loss and Damage in Vulnerable Countries Initiative" supports the Government of Bangladesh and the Least Developed Countries to call for action of the international community.

The Initiative is supplied by a consortium of organisations including: Germanwatch, Munich Climate Insurance Initiative, United Nations University Institute for Environment and Human Security (UNU-EHS), and the International Centre for Climate Change and Development (ICCCAD).

More info: **www.loss-and-damage.net**

United Nations University Institute for Environment and Human Security

The UN University (UNU), established by the U.N. General Assembly in 1973, is an international community of scholars engaged in research, advanced training and the dissemination of knowledge related to pressing global problems. The University operates a worldwide network of research and post-graduate training centres, with headquarters in Tokyo. UNU created the Institute for Environment and Human Security (UNU-EHS) to address and manage risks and vulnerabilities that are the consequence of complex - both acute and latent - environmental hazards including climate change - which may affect sustainable development. It aims to improve the in-depth understanding of the cause effect relationships to find possible ways to reduce risks and vulnerabilities. The Institute aims to establish cutting edge research on climate change and foster an internationally renowned cohort of up-and-coming academics. Based on the research-to-policy mandate of the UNU, UNU-EHS supports policy processes such as the UNISDR (disaster risk reduction), UNFCCC (climate change) and others, as well as national governments across the world with authoritative research and information.

More info: **www.ehs.unu.edu**

Kindly supported by the Climate Development and Knowledge Network (CDKN)