CLIMATE CHANGE, KING TIDES AND KIRIBATI

by

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ABSTRACT

The Pacific Region is particularly susceptible to prolonged natural disasters, including droughts and now, more recently, the combined effects of monthly wave surges known as "king tides." These long-term natural disasters constantly chip away at communities, straining traditional social support networks and exacerbating vulnerabilities of those who are already considered most vulnerable. Equipping individuals with the skills, knowledge and power to adapt to these imminent changes will strengthen their resiliency through change and improve their overall health. By highlighting the ways in which climate change is impacting the daily lives of individuals, we begin to understand the need for adaptation to occur at all levels of society, especially for extremely vulnerable populations, including the disabled, young children and the elderly. This paper looks at the impacts of climate change on health. Utilizing a Social Ecological Framework, the author will identify the public health significance of working within this model to inform adaptation policies, projects and plans can bring about positive changes in public health. Kiribati, a low-lying island nation in the Pacific Region, will be utilized as an example to show how targeting the different levels of the framework can improve health, which will require a systematic shift in adaptation implementation programs from being more infrastructure-based to being person-centered and rights based.

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LIST OF ACRONYMS

ADB	Asian Development Bank
GOK	Government of Kiribati
IFRC	International Federation of Red Cross and Red Crescent Societies
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
KAP	Kiribati Adaptation Project
KNSO	Kiribati National Statistics Office
NOAA	National Oceanic and Atmospheric Administration
SIDS	Small Island Developing States
SDG	Sustainable Development Goals
UN	United Nations
UNGAS	United Nations General Assembly
UNFCCC	United Nations Framework on the Convention on Climate Change
UNICEF	United Nations Children's Fund
US	United States
USAID	United Stated Agency for International Development
WB	World Bank
WHO	World Health Organization
WMO	World Meteorological Organization

PREFACE

Special thank you to my husband and children, also known as “Team Ambo,” for their support, patience, understanding and tenderness they have freely given me throughout the writing of this paper.

1.0 INTRODUCTION

Climates across the globe are constantly changing. In recent years, scientists who study climates have noticed that changes in our climates have been happening more quickly than in any other period in time. One of the most significant drivers for this change is the buildup of gasses like carbon dioxide into the Earth's atmosphere, which contributes to increased temperatures. These gasses are a result of human induced activities, such as the burning of fossil fuels (Ciaia, 2013; Intergovernmental Panel on Climate Change [IPCC], 2007; IPCC 2007; IPCC 2013; IPCC, 2014).

Impacts from changing climates can no longer be considered as solely environmental problems. These impacts are cross-cutting in nature, affecting economic, cultural, political and social sectors, causing cross-border challenges for neighboring countries that include refugee populations that stress natural and human resources, and marking climate change as a global issue of human security (Boston, 2009; Commission of Human Security, 2013; Government of Kiribati [GOK], 2009). Discourse on climate change has made a dramatic shift over recent years. Scientific rhetoric previously challenging the very existence of climate change has now shifted to identifying actions needed to minimize the effects of current impacts (Gore, 2007; IPCC,1990). The recent adoption of the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) from the 21st meeting of the Conference of Parties in December 2015 as well as the incorporation of climate related objectives and targets into the

Sustainable Development Goals are evidence of this change and mark an important paradigm shift (UN, 2015; UNFCCC, 2015). This shift clearly indicates that there are no longer questions related to if climate change exists. The questions are now related to what we can do to stop change from happening and how can affected communities adapt to changing climates.

This paper begins by defining climate change and gives a brief background of the global scientific and political context that surrounds our changing environments. Chapter two provides and discusses examples of the global environmental and health impacts of climate change. The environmental impact section details how human actions, like the increased use of fossil fuels and the release of greenhouse gasses into the environment contribute to higher temperatures, increased snow melt and the rise in sea-levels. The next section examines what the impacts of changing environmental conditions are on human health. Lastly, this paper addresses the Pacific Region and utilizes the country of the Republic of Kiribati as an example to highlight how environmental and health impacts of climate change combine to affect extremely vulnerable communities. By utilizing a social ecological model of health, the author details the social, cultural, and structural dimensions of health that are due to climate change. Ways forward for Kiribati are discussed and a call to action is issued.

2.0 CLIMATE CHANGE

2.1 DEFINING CLIMATE CHANGE

The weather we experience daily is influenced by many factors, including fluctuations in wind, clouds, temperature, and humidity levels. Climate is defined as daily weather averaged over a specific period of time (IPCC, 1990). Looked at this way, the Earth's climates are continually changing. This is witnessed through natural cooling and warming periods of time throughout history separated by several thousands of years, with the most recent warming period occurring over 125,000 years ago (Hoffman, 2017). Data have recently shown that climates are changing more rapidly than has ever been documented. Scientists first began to study climate change in the early 1820s with Jean-Baptiste Joseph Fourier when he suggested that the Earth's atmosphere must, in some way, capture the sun's rays to maintain terrestrial temperatures (Fleming, 1999). The Earth's atmosphere captures gasses and prevents heat from escaping the Earth. It was not until 1896 when a scientist named Svante Arrhenius linked climate change with levels of carbon dioxide. Arrhenius predicted that a doubling of atmospheric carbon dioxide concentrations would result in a 5-6 °C rise in the Earth's temperature (UppenBrink, 1996). Today, Arrhenius' prediction of increased temperatures has been confirmed, although current climate models are predicting 1.5 - 4.5 °C rise (Costello, 2009).

Climate change took longer to enter the realm of policy. In 1979, the World Meteorological Organization (WMO) in conjunction with The United Nation's Educational, Scientific and Cultural Organization (UNESCO), the Food and Agriculture Organization (FOA), the World Health Organizations(WHO) and the United Nations Environmental Programme (UNEP) held one of the world's first climate conference. This conference called on the scientific community to take action on climate variability and assess the impacts of how climate change affects human lives. The conference established working groups to assess various aspects of climate change, including the physical science, socio-economic impacts, and mitigation strategies.

The Intergovernmental Panel on Climate Change was created and endorsed by the United National General Assembly (UNGAS) in 1988. The overarching goal of the IPCC was to assess the scientific rhetoric and the potential impacts of "certain human activities that could change global climate patterns and threaten future generations with potentially severe economic and social consequences" (p. 1). In 2007, the IPCC (2007) released a landmark report that confirmed these threats: "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising average sea level…There is very high confidence that the global average net effect of human activities since 1750 has been one of warming" (p. 4). This report, arguably one of the most comprehensive, transparent, and in-depth works on climate change, detailed the science behind climate change, providing statements of support describing their level of confidence that major statements and outcomes will occur, as well as data-based case-studies.

Building on the work of the IPCC, to date, there have been numerous international meetings, conventions and negotiations culminating in three important documents: United

Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement. The UNFCCC, also known as 'The Convention,' is an international treaty adopted in Rio de Janeiro at the Earth Summit in 1992. The Convention came into force in 1994 and at the time of this writing had 197 ratifying parties (2017), which makes the Convention one of the highest endorsed treaties in the world. The text of the Convention defines important language used in climate change discourse. One of the most notable, is the definition of climate change: "a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable times" (UNFCCC, 1992, p. 7).

The overarching objective of the Convention is to chart a path to

> Achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally and to enable economic development to proceed in a sustainable manner. (UNFCC, 1992, p.9).

The Convention outlined steps parties should take towards minimizing gas emissions by 1998 and called for developed countries to establish new funds for climate change activities in developing countries to mitigate the effects and to assist in the transfer of technology to support less-developed nations (UNFCC, 1992).

The Kyoto Protocol, developed in 1997, came into force in 2005. The protocol set the stage for decreasing global carbon emissions, effectively operationalizing the UNFCCC (UNFCCC, 1997). The protocol acknowledged that developing countries, as a result of industrialism, were mostly responsible for the current atmospheric levels of greenhouse gas emissions. Greenhouse gasses include water vapor with carbon dioxide, methane, nitrous oxide and ozone. When these gasses are dispersed into the atmosphere in excess they become trapped. This effectively disrupts the natural atmospheric balance and contributes to increases in global temperatures (IPCC, 2013; Costello, 2009). The protocol established internationally binding reduction targets that recognized the responsibility of developed nations due to their contribution to high atmospheric greenhouse gas emissions over the past century. The protocol offered parties market-based mechanisms to help offset their carbon emissions, including emissions trading, clean development movements and join implementation (UNFCCC, 1997).

Former United States Vice President and environmental activist Albert Gore produced a documentary in 2006 titled, "An Inconvenient Truth", which presented available data to support global warming and stressed anthropogenic activities as the cause (2006). This film was a stark call to action for both the national and international communities. With significant grassroots support for a binding agreement and consensus to stop and reverse global warming and carbon emissions, the 2015 Paris Agreement established a firm global commitment to keep global temperature rise in this century below 2°C above pre-industrial levels, pursuing efforts to decrease further to 1.5 °C. The Agreement supports a transparent process of review, with global stock taken every five years to monitor progress, and defines how financial and technology transfers to developing countries will be tailored to be more closely align with these countries' national objectives (UN, Paris Agreement, 2015).

2.2 IMPACTS OF CLIMATE CHANGE

2.2.1 Environmental Impacts of Climate Change

The IPCC reports detailed in-depth changes in the environment due to climate change. This paper will highlight three of the major changes witnessed globally: increased temperatures, melting snow and ice, and rising sea levels. These three environmental impacts, exacerbated by human activities, are generating a cause and effect spiral that is charging towards an unknown tipping point while leaving a trail of socio-economic disasters along the way. The root cause of these three changes is linked to global warming and human activities.

Greenhouse gas emissions are a driving force for global climate change. Gasses like carbon dioxide, which result from the burning of fossil fuels, get trapped in Earth's atmosphere (Ciaia et al., 2013; Keeling et al., 2005; Kennedy, 2016). As sunlight enters the atmosphere, the Earth absorbs some of this energy, which heats the ground. The energy that does not get absorbed is reflected back towards the sun. The trapped gasses in the Earth atmosphere contribute to higher global temperatures through the absorbtion of a portion of this energy. If greenhouse gasses are emitted without regulation, weather patterns will become increasingly more intense (Meduna, 2016). Human activities such as deforestation, burning of fossil fuels, and increased manufacturing have contributed to increased greenhouse gas concentrations in the Earth's atmosphere. Figure 1 shows the Keeling Curve, which graphs the drastic increases in carbon dioxide levels measured from 1958 – 2017 in Mauna Loa, Hawaii (Keeling, 2005).

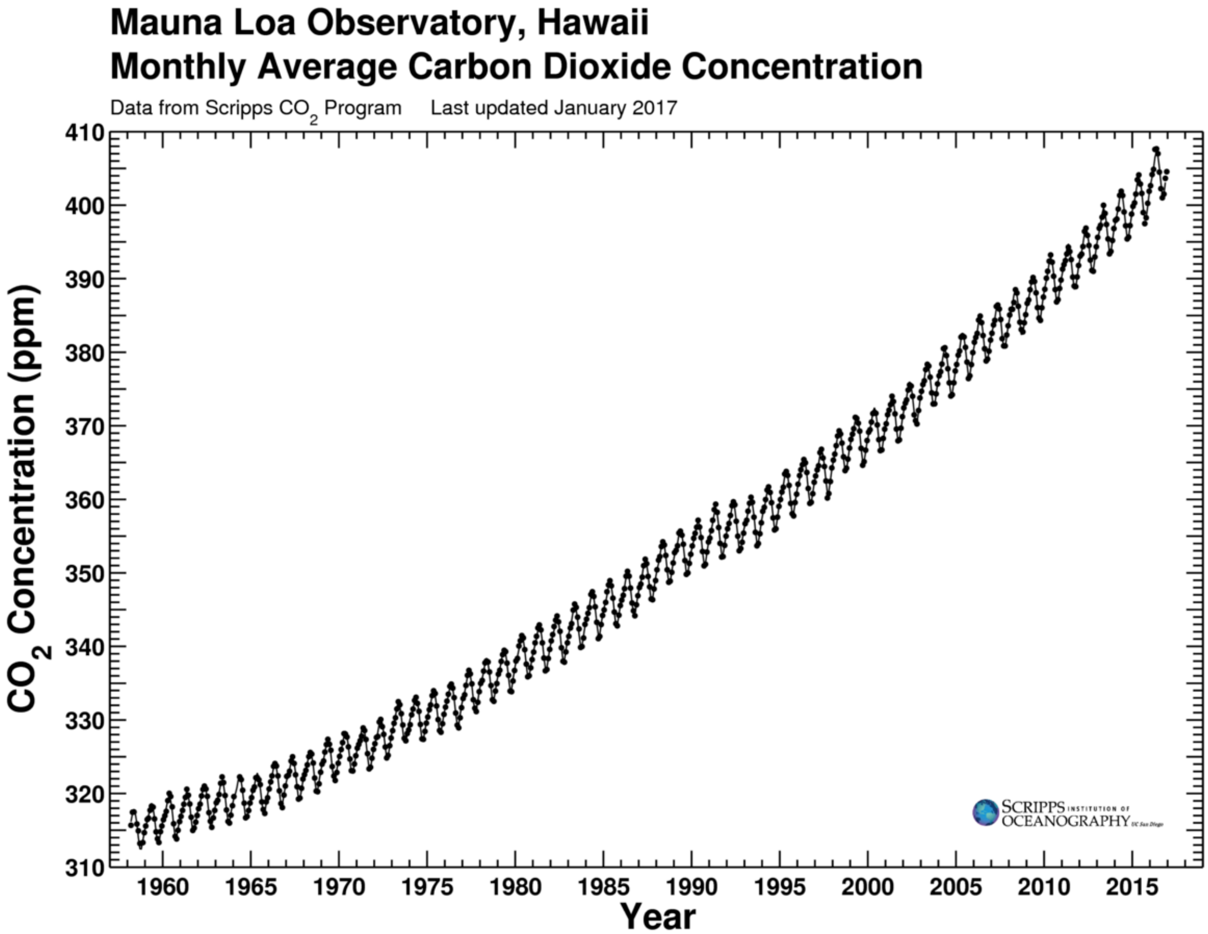

Figure 1. Monthly Average Dioxide Concentration from 1958 – 2017.

Reprinted from Scripps CO2 Program, by Charles D. Keeling, 2017, retrieved January 2017 from **http://scrippsco2.ucsd.edu/history_legacy/keeling_curve_lessons** . Copyright 2017 by the Scripps Institute of Oceanography. Reprinted with permission.

The IPCC's First Assessment Report from 1990 lists pre-industrial (pre-1800) atmospheric carbon dioxide levels at 280 ppm. Pre-industrial revolution levels of carbon dioxide levels were built up over thousands of years and were analyzed via core ice samples from Greenland and the Antarctic and by 1958, carbon dioxide levels had risen to 315ppm (IPCC, 1990). By 1994, as documented in the IPCC Second Report, carbon dioxide levels had risen to

358ppmv, which produced an average rate of concentration of 1.5 ppm per year (IPCC, 1995). The Fifth Report documents 2011 levels at 390.5ppm (IPCC, 2014), demonstrating that human activities have contributed to an increase of greenhouse gases in Earth's environment more quickly during recent years than any other period in time. Costello (2009), confirm this in their LANCET article on 'Managing the Health Effects of Climate Change, saying, "the pollution we have caused in one century is thus comparable to natural variations that have taken thousands of years" (p.1698). It will take several generations for the Earth to return to a healthy balance of carbon in the atmosphere, even longer if carbon emissions continue to climb as they have over the last few decades.

Analysis of climate change data over time shows an increase in global temperatures. This global warming effect is attributed to greenhouse gases being released into the environment, air and ocean, becoming trapped in the Earth's atmosphere causing temperature increase, and thereby creating warmer climates. Average temperatures around the world currently mirror the dramatic rise in atmospheric carbon levels shown in Figure 1. Figure 2 depicts global land and ocean temperature anomalies between the years 1880 -2015. These data from the National Oceanic and Atmospheric Administration (NOAA) show that global temperatures have risen significantly over this time period, and more so since the late 1970s. The WMO has confirmed that 2016 was the hottest year on record, being 0.07°C above the historic temperature set only a year earlier in 2015 (WMO, 2017). This means that global temperatures have been surpassing historic highs for the past three years.

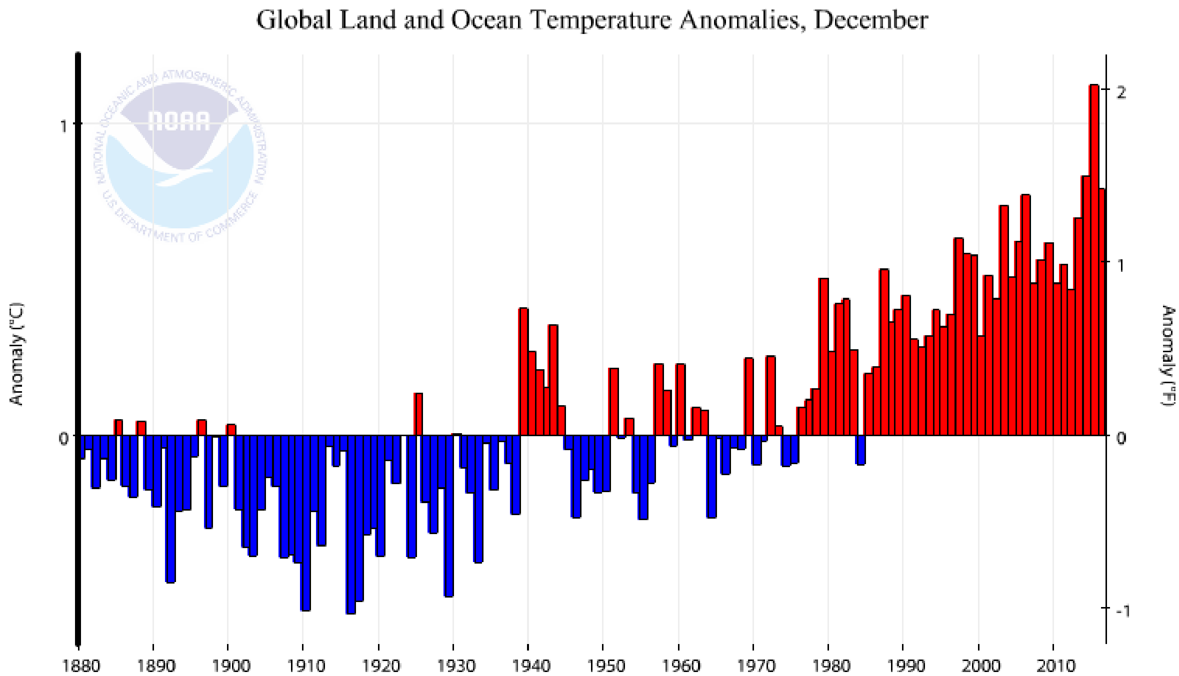

Figure 2. Global Land and Ocean Temperature Anomalies.

Reprinted from NOAA National Centers for Environmental Information: Climate at a Glance: Global Time Series. Retrieved January 21, 2017. Retrieved from National Centers for Environmental Information: **http://www.ncnc.noaa.gov/cag/**. Reprinted with permission.

Warmer temperatures cause glaciers, snow covers and ice caps to melt. Land-based glaciers and ice sheets are in decline, which affects water availability and exacerbates sea-level rise. Figure 3 shows data from the Environmental Protection Agency (EPA) on glacier mass from the World Glacier Monitoring Service. Even though the overall number of glaciers that were monitored, depicted in the bottom graph, increased from the 1950s to the mid-1980s, the total mass of these glaciers has declined. This decline has accelerated, as shown in the top figure (EPA, 2016; WGMS, 2015).

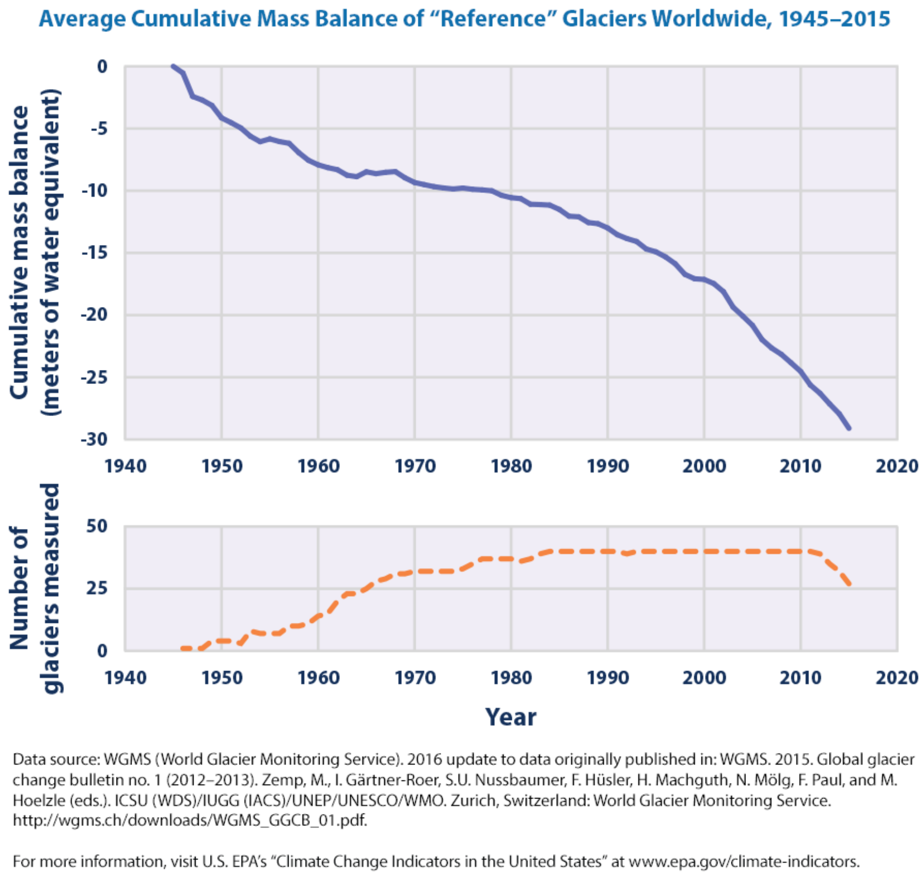

Figure 3. Average Cumulative Mass Balance of "Reference" Glaciers Worldwide, 1945 - 2015

Reprinted from United States Environmental Protection Agency. Reprinted from United States Environmental Protection Agency: Climate Change Indicators. Retrieved on January 22, 2017, from https://www.epa.gov/climate-indicators/climate-change-indicators-glaciers#ref3 .

The WMO Secretary General Petteri Taalas stated in a press release in January 2017: "The Arctic is warming twice as fast as the global average. The persistent loss of sea ice is driving weather, climate and ocean circulation patterns…" (WMO, 2017). When both land and sea waters melt, they empty into the seas, disrupting ocean salinity and currents, ocean water temperatures increase to match hotter air temperatures. Through thermal expansion, warmer water volume increases, which contributes to sea-level rise.

With 2016 being the hottest year on record, it was also the year with the lowest levels of sea-based ice. An analysis of global average sea ice measurements from the Arctic and Antarctic between 1979 - 2013 showed that there has been a decline both seasonally and monthly (Parkinson, 2014). This means the average of global sea ice build-up is declining. According to the National Aeronautics and Space Administration (NASA) Earth Science News Team member Maria-Jose Viñas, this decline has accelerated, nearly doubling between 1996 -2013 (2015). The average annual loss since 1979 equates to 13,500 square miles, which is similar to losing sea ice equal to the US State of Maryland annually (Viñas, 2015).

2.2.2 Health impacts of climate change

As increased amounts of greenhouse gases are emitted into our environment, changing our climates, human lives are impacted in significant ways. In the previous section of this paper, three significant environmental impacts of climate change were discussed: increased temperatures, melting snow and ice, and rising sea levels. This section will discuss some of the health impacts related to two of these environmental impacts: increased temperatures and the melting of snow and ice.

Changes in climates around the world will have devastating impacts on health and human security (Boston et al., 2009; Commission of Human Security, 2013). Rising temperatures contribute to drought conditions and longer periods between seasons of rain. Agricultural lands that once produced bountiful yields are becoming drier. Water sources used to maintain production yields are becoming limited or non-existent. When environments become arid, the ability to grow food is significantly diminished. Dry land becomes less viable to grow crops, and livestock must be herded farther away from homes in search of land for grazing. Individuals are therefore forced to work harder and longer to maintain agricultural production levels to ensure their own survival, let alone have any products left for income generation.

The 2016 Global Nutrition Report by the International Food and Policy Research Institute (IFPRI) suggests that malnutrition is the main driver of the global disease burden. The report goes on to say that by the end of the century the "economic consequences [of malnutrition] represent losses of 11% of gross domestic product every year in Africa and Asia" (IFPRI, 2016, xvii). One source estimated that "harvest staple food crops, such and rice and maize, could fall between 20% to 40%, as a result of increased temperatures during growing season in tropical and sub-tropical regions" (Costello, 2009, p.1704). As staple crop production decreases with rising temperatures, rates of malnutrition will subsequently increase. With nearly every country across the globe experiencing on-going nutritional crises, either from overnutrition, undernutrition or both, a decrease in useable agricultural land and crop production will negatively impact human health and jeopardize global food security (IFPRI, 2016; Costello, 2009).

Warmer temperatures contribute to a change in the distribution of vectors that transmit disease (CDC, 2017; Costello et al., 2009; Musso et al, 2014). Short life cycles and the ability to quickly reproduce make mosquitoes very adaptable to changes in climates, especially to warmer climates. Even the most minute changes in an environment can influence the numbers and geographic presence of animals and insects (Costello, 2009; Gillies, 1953, Reiter, 2001). Gillies, as cited in Githeko (2000), states that "If water temperature rises, the larvae take shorter time to mature and consequently there is greater capacity to produce more offspring…adult female mosquitoes digest blood faster and feed more frequently thus increasing transmission intensity" (p. 1137). Changing precipitation levels can also have an effect on the numbers of mosquitoes in any given area by increasing the number of breeding sites available to reproduce.

With the combination of increased higher temperatures and rain, mosquito populations will have increased breeding ground availability and can mature faster, which means an increased risk of exposure to biting of humans. Mosquitoes are known vectors for such diseases as chikungunya, malaria, dengue fever, Zika and several types of encephalitis, that are mostly caused by viruses which reproduce in mosquito saliva and are transmitted to humans through the biting process (Gillis, 2016, CDC, 2016). Humans who become infected with these viruses subsequently fall ill. As climates warm, mosquitoes that transmit these viruses can adapt and spread to geographical locations where they have not existed previously, increasing the risk of exposure for human populations that were previously free from such diseases, also known as emerging infectious diseases.

Chikungunya, Zika and dengue fever are three examples of emerging diseases. Leading global health organizations estimate that up to 40% of the world's population are at risk of dengue virus and that nearly 400 million people are infected with dengue annually (CDC, 2017; WHO, 2017). Chikungunya cases were documented in the Indian Ocean Islands in 2005, and by 2013 had already stretched across the globe to the Caribbean Islands by 2013 (Cao-Lormeau, 2014). Zika was virtually nonexistent in the Pacific Islands Region before 2005. The Pacific Region saw outbreaks of Zika long before the larger, more well-known 2015 outbreaks in Brazil, which eventually led the WHO to declare a global international public health emergency in 2016 (Musso et al, 2016; WHO, 2016). Outbreaks of Zika were reported outside of Asia for the first time in the Federated States of Micronesia and in the State of Yap in 2007 followed by French Polynesia in 2013 and 2014 (Cao-Lormeau, 2014; Duffy, 2009). The initial outbreak in French Polynesia in 2013 consisted of only a few cases, while the 2014 outbreak had an estimated 28,000 - 30,000 symptomatic infections (Musso et al., 2014, 2015; 2016). The dramatic jump in case counts separated by a few short months can be attributed to a number of things including increased air transportation and potential imported cases, and most notably climate change, demonstrating the ability of mosquitoes to readily adapt to changing climates.

At the time of this writing, March 2017, the CDC reported cases of mosquito-borne Zika transmission in nine Pacific Island Countries (CDC, 2017). As of April 2017, CDC reported chikungunya present in ten (CDC, 2017). While case fatality rates of denge fever have decreased due to increased health promotion and awareness campaigns since 1992, Figure 4 shows that the total number of reported cases has increased steadily in the Western Pacific Region from the year 2000, with an outbreak in 2009 that spanned 14 countries in the region with high incident rates reported in at least five (Arima, 2013). As temperatures continue to rise, mosquito populations continue to adapt, increasig the risk of exposure to emerging diseases.

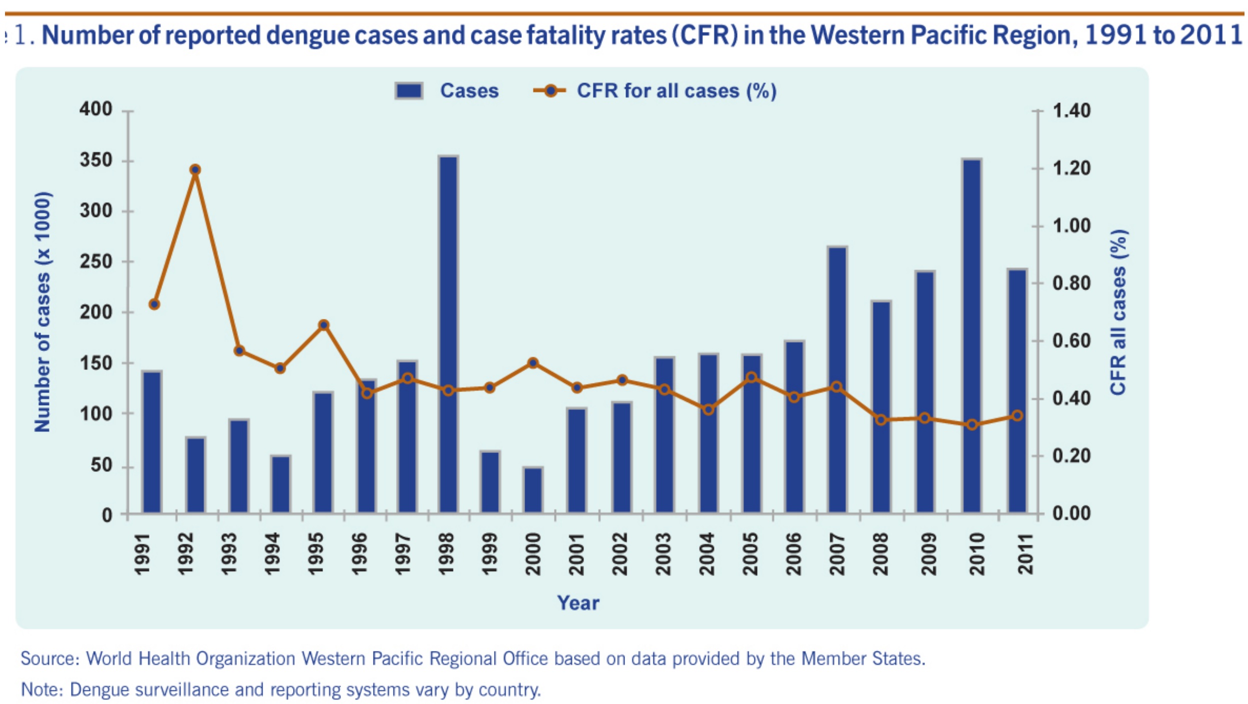

Figure 4. Number of Reported Dengue Cases and Case Fatality in the Western Pacific Region, 1991 – 2011.

Reprinted from Arima Y, Chiew M, and Matsui T. Epidemiologic update on the dengue situation in the Western Pacific Region. *Western Pacific Surveillance and Response Journal* 2013;1-8. doi:10.5365/wpsar.2012.2.4.019.

It is estimated that approximately one sixth of the Earth's population lives in close proximity to glacially fed water catchment areas (Costello et al., 2009). Changing patterns of water cycles that include the melting of snow and global ice reserves contribute to fresh water accessibility issues due to, but not limited to, non-seasonal flooding and inadequate fresh water availability. When these areas experience exceptionally warm temperatures, the glacial snow and ice build-up melts. This can cause an extreme flooding event downstream during times when people are not prepared. This non-seasonal flooding contributes to water scarcity. With less snow available in the higher elevations during the drier seasons, there is less snow to melt for human consumption. Slowly over time, a geographical area that was once bountiful with clean water has less water available. The main health effect is diarrheal diseases due to a lack of sanitation and clean water. A variety of diseases are contracted through contaminated water as a result of decreased sanitation including cholera, typhoid and dysentery. When glaciers and snow melt occur in these areas, approximately 1.2 billion people are at risk for potential exposure to contaminated water, which increases their risk for contracting waterborne diseases (Costello et al, 2009).

2.2.3 Impacts in the Pacific Region

Straddling the Ring of Fire, the Equator and the International Date Line, the Pacific is one of the most vulnerable regions in the world. Cyclones, tropical storms, earthquakes, tsunamis, volcanoes, drought, as well as civil unrest are only a few of the hazards that are endemic to the region. Natural disasters have affected more than 3.4 million people in the Pacific Region since 1950, costing the Pacific Region over 2.8 billion US dollars, between 2-7% of their total Gross Domestic Product for both disaster and non-disaster years (Bettencourt, 2006). Global climate change funds made available through the UNFCCC for the Pacific Region, which includes Kiribati and ten neighboring countries, is only 4.6% of the total available funding for the East Asia and Pacific Region, which has mostly been targeted for adaptation activities (Barnard, 2014).

Small island developing states, like those in the Pacific, are limited in size and remote in nature, making them extremely vulnerable to both internal and external shocks, or an unexpected change in an economic or socio-economic factor that occurs inside or outside of a country (IPCC, 2007). Examples of external shocks are changes in global food or oil prices, or external transportation issues and internal shock examples include natural or manmade disasters. The Economic Vulnerability Index, or the risk posed to these countries by external shocks, is calculated utilizing a variety of indicators that measure exposure and impact of both economic and natural shocks. The World Bank Database called Stat Planet reports the EVI for countries in the Pacific Region that range from 32.1 for Papua New Guinea to 38.8 for Fiji, 67.9 for Nauru, and 71.5 for Kiribati and are shown in Figure 5. The higher the score, the more severe external factors will impact the country (World Bank, 2015). As this figure shows, Kiribati, Palau and Nauru are the three countries in the Pacific Region that are most vulnerable to external shocks, while Fiji, Papua New Guinea and Samoa are more resilient to these shocks.

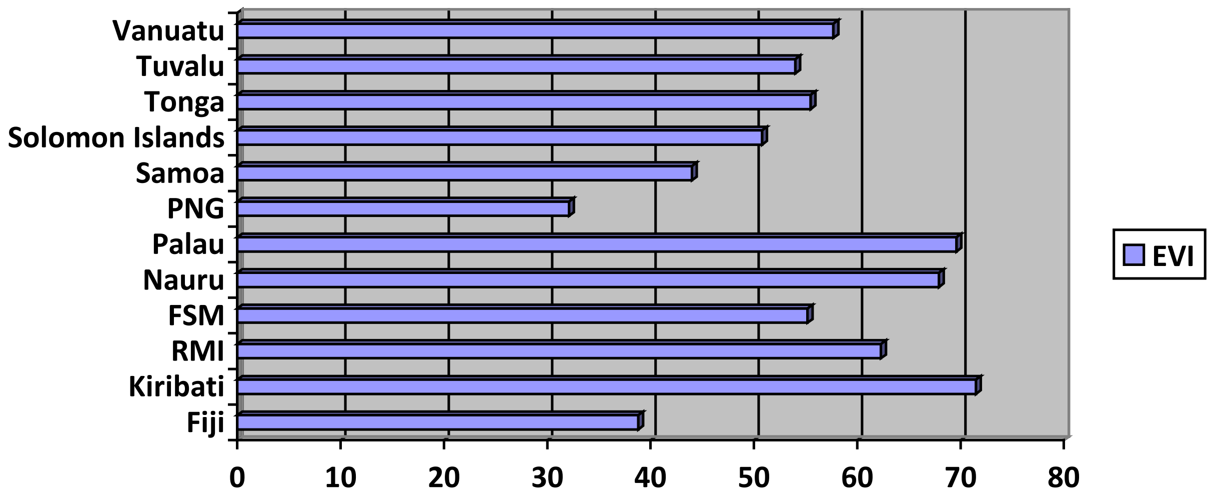

Figure 5. Economic Vulnerability Index Rankings for Select Pacific Islands Countries.

Reprinted from Stat Planet Word Bank – Open Data by World Bank via StatSilk, 2017, Retrieved 15 January 2017 from **http://esango.un.org/sp/ldc_data/web/StatPlanet.html** . Open Data Source: World Bank 2015

Fish is a staple source of protein in Pacific Island diets. This abundant and culturally significant resource also provides opportunities for tourism, development and trade. When fish stocks like tuna are low, socio-economic shocks can be seen in the economies of countries with high EVI, like Kiribati, Palau or Nauru. The lack of fish means less food to balance diets, less fish to sell and fewer fisherman traveling to the island for tourism.

Fish stocks can also be affected by ciguatoxins. Ciguatoxins are produced by dinoflagellates that eat algae on coral reefs and thrive in warmer waters. These toxins are odorless and tasteless and are not affected by cooking or preserving processes. When ingested these toxins cause symptoms similar to food poisoning with neurological sensitivities that can last for months or years after initial symptoms have subsided. Increased disturbances related to climate change including increased extreme weather, such as cyclones and tsunamis, or increasing sea temperatures such as coral bleaching and algae blooms contribute to the disruption of coral reefs, which in turn impact the growth of ciguatoxin microalgae (Gingold, 2014: Goater, 2011). Fish eat the toxic microorganism, which accumulates the toxins in the fish. Humans eat the toxic fish and become ill. Referring back to Figure 2, land and ocean temperatures began a significant increase during the mid to late 1970s and continued this increase through out the 1980s, 1990s and 2000s. Figure 6 shows ciguatera fish poisoning incidences assessed from seventeen Pacific Island Countries and Territories between 1973-1983, and from 1998 – 2008 (Skinner, 2011). This first timeframe corresponds to the initial onset of increased global temperature anomolies and the second timeframe corresponds to almost 20 years of global temperature anomoly increase. Figure 5 shows a 60% increase in the mean incidence of ciguatera fish poisoning between the two different time frames. The more fish that ingest ciguatoxins, the higher the risk of exposure for Pacific Islanders, who depend on reef fish for food, traditional ceremonies, income generation and livelihoods. This increased incidence of ciguatera fish poisoning negatively impacted the health of Pacific Islanders by increasing rates of ciguatera fish poisoning from the time global land and ocean temperature anomalies first started changing in the mid-1970s. This means that one of the main drivers for this change is climate change.

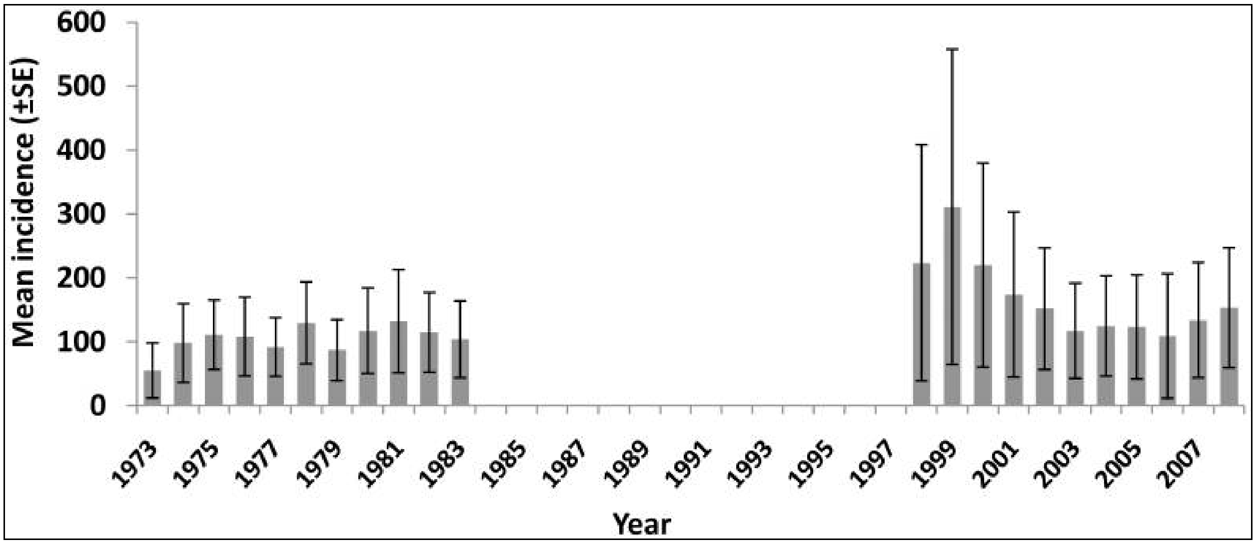

Figure 6. Incidence of Ciguatera Fish poisoning in the Pacific 1973 – 2008.

Reprinted from "Ciguatera Fish Poisoning in the Pacific Islands (1998 to 2008)," by Mark Skinner, et al. December 2011 PLoS Neglected Tropical Diseases 5(12): e1416. Doi: 10.1371/journal.pntd.0001416. Copyright 2011 Skinner et al. Reprinted under Creative Commons License.

Historically, natural disasters have been associated with one-time events with initial impacts that range anywhere from a few minutes to a few days in duration with recovery lasting much longer. The Pacific Region is particularly susceptible to prolonged natural disasters, including droughts and more recently, the combined effects of a changing climate. These long-term, slow-moving natural disasters constantly chip away at communities, straining traditional social support networks and exacerbating vulnerabilities of those who are already considered most vulnerable. Utilizing World Bank Database information, Figure 7 shows the share of the population (per 100,000) averaged over the past 20 years that has been a victim of natural disasters (WB, 2017). Kiribati and Vanuatu are two of the region's countries that have been the most affected by natural disasters over the past 20 years.

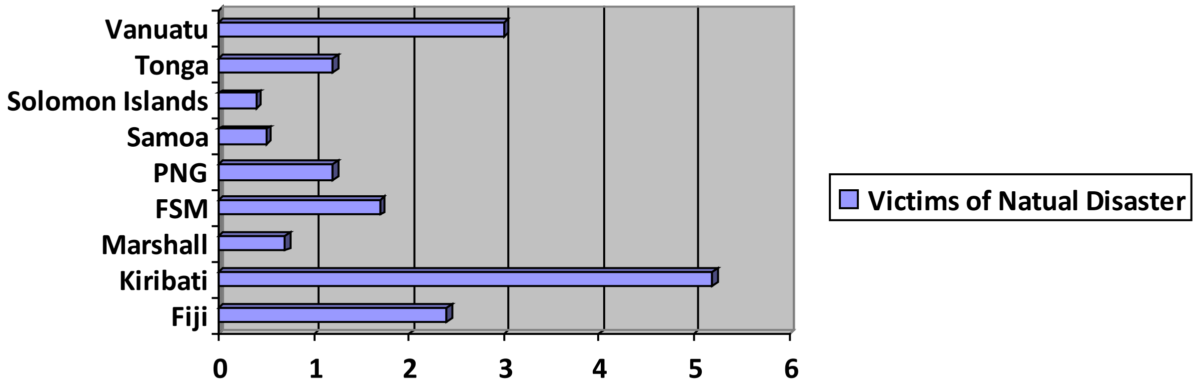

Figure 7. Victims of Natural Disasters (per 100,000) averaged over 20 years.

Reprinted from Stat Planet Word Bank – Open Data by World Bank via StatSilk, 2017, Retrieved from Retrieved from http://esango.un.org/sp/ldc_data/web/StatPlanet.html . Open Data Source: World Bank, 2015

Pacific Island Countries have minimally contributed to the root causes of climate change, yet are some of the first to suffer from the direct impacts. Over the last 60 years, natural events alone have caused over $3.2 billion USD in damage and have affected over 9.2 million people across the Pacific Region (Pacific Catastrophe Risk Assessment and Financing Innitiative [PCRAFI], 2015). The World Bank estimates that "the average annual loss caused by natural hazards across all 15 Pacific Island Countries is estimated at $284 Million USD, or 1.7% of all regional GDP" (PCRAFI, 2013, p.7). Impacts of the changing climate witnessed across the Pacific Region include an increase in the number, intensity and changes in seasonal patterns of natural disasters, including tropical storms, cyclones, droughts, and tidal surges and overall higher temperatures (IPCC, 2007). While cyclones can form at any time during the calendar year, cyclone season officially runs from November to April. The Pacific Region normally will see an average of four or five cyclones per season, which includes hurricanes, tropical depressions and storms. For cyclone season 2015, the Pacific Disaster Center (PDC) predicted five to eight cyclones with a 70% chance of an above normal season (PDC, 2015). By July 2015, this prediction had already been met. A total of eight tropical storms were active in the Pacific basin, five of which occurred within the same week, one of which was rated as a Category 4[1] hurricane (NOAA National Centers for Environmental Information, 2017).

Interaction between trade winds and both the Intertropical and the South Pacific Convergence Zones causes fluctuations in the weather patterns known as El Niño and La Niña. El Niño periods are associated with wetter and warmer weather, while La Niña periods are associated with dryer and cooler weather (Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organization [CSIRO], 2011). Drought conditions during La Niña weather patterns in 2011 and 2015 sparked regional concern for over ten Pacific Island Countries and required international emergency responses in at least two (Australian Broadcasting Company, 2011; United Nations Office for Coordination of Humanitarian Affairs [UNOCHA], 2016; 2011). Tuvalu rationed fresh water to families to two buckets a day, before international assistance was requested and made available (Chua, 2011; Economist, 2011; New Zealand Defense Force, 2011).

According to the National Oceanic and Atmospheric Administration (NOAA), the 2016 cyclone season saw ten total storm systems across the Pacific Region. Category 4 and 5 cyclones have more than doubled in the South-West Pacific Region since 1975 (Webster, 2005). Superstorm Pam of March 2015 and Cyclone Winston of February 2016, both classified as Category 5 storms, were only eleven short months apart and were two of the region's strongest

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[1] The Saffir-Simpson Scale uses a five-point scale to measure intensity of hurricanes. Category 1 Hurricane is the lowest intensity and Category 5 being the strongest.

storms ever recorded (International Federation of Red Cross and Red Crescent Societies [IFRC], 2015; UNOCHA, 2016). These storms caused widespread damage to several countries across the region.

Superstorm Pam decimated Vanuatu and sent tidal surges across the entire Pacific Region, including countries that are historically located outside normal storm pathways, like Kiribati (IFRC, 2015; United States Agency for International Development [USAID], 2015). Cyclone Winston traveled an erratic path, crossing over Tonga twice and wiping entire Fijian villages off the map. At the time of occurrence, Winston was recorded as the strongest cyclone ever to make land fall with wind gusts clocking over 220 miles per hour causing storm surges up to 12 feet (UNOCHA, 2016). The high winds of intense storms churn open ocean and lagoon waters creating higher than normal waves that crest and fall with powerful force. When these waves hit land, the water surges onto the land and can cause significant undertow and coastal erosion when the waves retreat to the main body of water. Storm surge drowning was found to be the primary cause of cyclone-related death world-wide between 1980 and 2009 with females in less developed countries linked with a higher risk of mortality (Doocy, 2013).

3.0 KIRIBATI, CLIMATE CHANGE AND HEALTH

3.1 KIRIBATI BACKGROUND

One of the nations most severely impacted by climate change is The Republic of Kiribati, one of the Pacific Island Countries (see Figure 8). Kiribati consists of 33 low lying coral atolls, peppered across over 1.93 million square miles of the Central Pacific Ocean. Bairiki, the capital city, is located on the island of Tarawa. The 21 inhabited atoll islands can be broken down into three different geographically based areas including the Line Group, the Phoenix Group and the Gilbert Group. Kiribati straddles the International Date Line and the Equator, and balances portions of its border across all four of the Earth's hemispheres. The country has a total land mass of only 312.9 square miles (Kiribati National Statistics Office [KNSO], 2012). This is approximately one fourth of the total land mass of the smallest state in the United States (US), Rhode Island (see Figure 9) and covers the same distance as New York to Los Angeles (Australian Government, 2015).

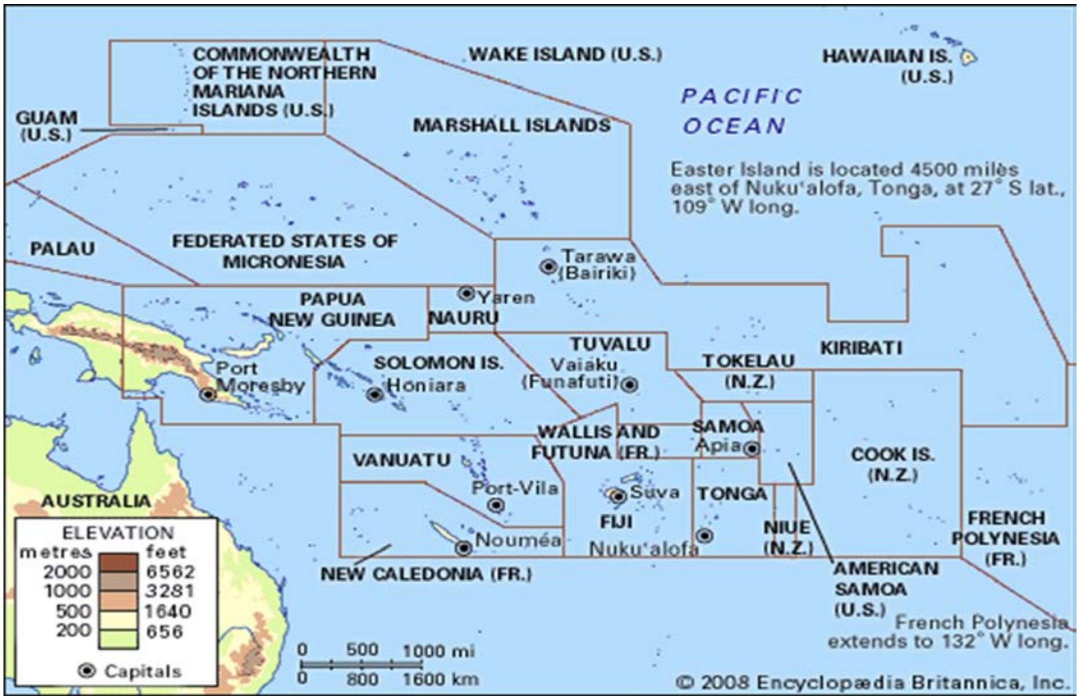

Figure 8. A Map of Pacific Island Countries.

Reprinted from Encyclopedia Britannica. Pacific Islands. [Map]. In Encyclopedia Britannica, 2008, Retrieved from **https://www.britannica.com/place/Pacific-Islands?oasmld=61639** . Copyright 2008 Encyclopedia Britannica. Reprinted under approval of terms of use.

Figure 9. Map of Kiribati and the United States of America.

Reprinted from billtrips.com by Wm Adams, 2015, Retrieved from **http://www.billtrips.com/2015/07/kiribati.html** . Copyright 2015. Reprinted under Creative Commons Attribution-Non-Commercial-No Derivatives 4.0 International License.

There are two urban centers in Kiribati. Kiritimati Island is in the Line Island Group and Tarawa Island is in the Gilbert Group. These urban centers are separated by thousands of miles, requiring a flight through at least one transit country or a seven-day cargo ship journey with good winds and calm seas. The southern end of Tarawa Island, known as South Tarawa, is home to over 50% of the country's total population and has a growth rate of 4.4%. Average population density is approximately 1,602 people per square mile nationally, with approximately 4,097 people per square mile in densely populated areas of South Tarawa (ADB, 2011; Government of Kiribati, 2010). All islands in Kiribati have become increasingly dependent on imported goods, including food staples such as rice, flour and tinned meats, as well as for fuel to meet transportation needs (Bataua, 1985). Shortages of staple items occurs frequently.

The islands of Kiribati are extremely susceptible to even minute changes in weather patterns, such as El Niño or La Niña. Development challenges for Kiribati are significant. The remote and isolated nature of these islands slows development in the health sector because of high maintenance costs for essential services including shipping and communication. Transportation is not only a challenge between islands, but also within the same island. Most islands have only one dirt road running the length of the island. Figure 10, shows one example of the small islets that string together forming narrow strips of land that comprise the Kiribati. Motorboats must be utilized to reach small islets that do not have roads connecting them to their main islands and are too small for an air strip to allow for planes (IMF, 2015).

Figure 10. Aerial View of South Tarawa, Kiribati. One main road connects a series of small islets.

Photo Credit Raimon Kataotao/ Humans of Kiribati. Reprinted with permission.

Having gained Independence in 1979 from the British, Kiribati is a democratically run country that operates a centralized government based out of the capital island of Tarawa in the Gilbert Group. The inhabitants of Kiribati are of Micronesian descent and speak the national language of Gilbertese. English language classroom instruction begins in the early primary years of formal education. At last census in 2010, Kiribati had a total population of 103,058, with slightly more females than males and a national population growth rate of 2.2% (Asian Development Bank [ADB], 201; KNSO, 2012).

Kiribati, like many small island developing countries, lacks the infrastructure, capacity and financial resources to devote to a full-time national disaster risk management office, resulting in several donor-funded projects related to disaster and risk management. Historically, this has not been a problem, as most of the disasters that Kiribati has experienced have been slow-moving emergencies like a drought, that give time to prepare for a response, should one be needed. With the recent increase in coastal flooding and king tides, there is a demonstrated need for a National Disaster Management Office. Building on a Disaster Management Act from 1993 and two successive Disaster Management Plans, Kiribati compiled a National Disaster Risk Management Plan (Government of Kiribati [GOK], 1993; 2012). This plan, using a legal and regulatory framework, establishes roles and responsibilities within a disaster context. This includes events related to climate change for government and non-government organizations and institutions and distinguishes between sudden onset and slow onset events (GOK, 2012; United Nations Children's Fund [UNICEF], 2012).

The Kiribati Adaptation Program (KAP) has been operating in Kiribati since 2003. Much of the focus of the KAP has been to document impacts of climate change, improve island infrastructure, strengthen policy, and improve internal government systems (Schalatek, 2015; WB, 2009: WB 2011). While these areas of focus are important, there is growing concern that individuals, families and communities are not getting the assistance they need to adapt to the changing climate. Coastal communities and residents living near rivers and streams are considered extremely vulnerable due to increased king tides, storm surges, and the increased potential of flooding.

3.2 SOCIAL ECOLOGICAL FRAMEWORK IN KIRIBATI

At the World Conference on the Social Determinants of Health in 2008, the WHO defined the social determinants of health as the “conditions in which people are born, grow, live, work, and age...and encompass the social, economic, political, cultural and environmental determinants of health" (WHO, 2011, p. 80). Key recommendations from this conference included improving daily living conditions, tackling the inequitable distribution of power, money and resources and finally, measuring and understanding a problem and assessing the impact of action. To fully understand how to effect change of the social determinats of health, we must look at how individuals and communities are influenced to change their behaviors or act on improving their conditions.

The WHO Ottowa Charter for Health Promotion states, "Our societies are complex and interrelated. Health cannot be separated from other goals. The inextricable links between people and their environment constitute the basis for a socioecological approach to health" (WHO, 1986, p.2). Social ecological approaches maximize health interventions by targeting social interactions between the individuals, their environment and the policies that govern them (Bronfenbrenner, 1975; McGinnis, 2014; McLeroy, 1998). The Social Ecological Model of Health includes both intrapersonal and interpersonal interactions. Intrapersonal factors include beliefs, biological and psychological make-up, attitudes and practices. These make an individual unique. Intrapersonal factors are the forces that influence changes to interpersonal factors, which includes communities, organizations, policies and social groups (Sallis, 2008). In Kiribati, motivation to make changes to interpersonal factors happens through the social interactions between several levels of influence and can evoke both positive and negative changes in health. In order for change to be sustainable and effective, health interventions that target multiple levels of influence are recommended.

According to Roman (2013), "Unlike societies which stress individualism over collectivism, Kiribati emulates the social paterns found across Micronesia, which are made up of extensive webs of interdependent relationships that support indivuiduals" (p.18). By utilizing a social ecological model of health, we begin to untangle these relationship webs, to see how health interventions, in the context of climate change, can be targeted to promote improved health in Kiribati. There are five levels of influence in Kiribati. Depicted in Figure 11, these levels are: Individual, Family, Organizations, Community and State. Each circle in this diagram refers to a significant level of influence that has the potential to effect change or influence action. Each level suggests a specific audience for health interventions that can have an impact on the social determinants of health. As Kiribati's climate continues to change, the importance of working within these levels of influence to encourage adaptation will become essential.

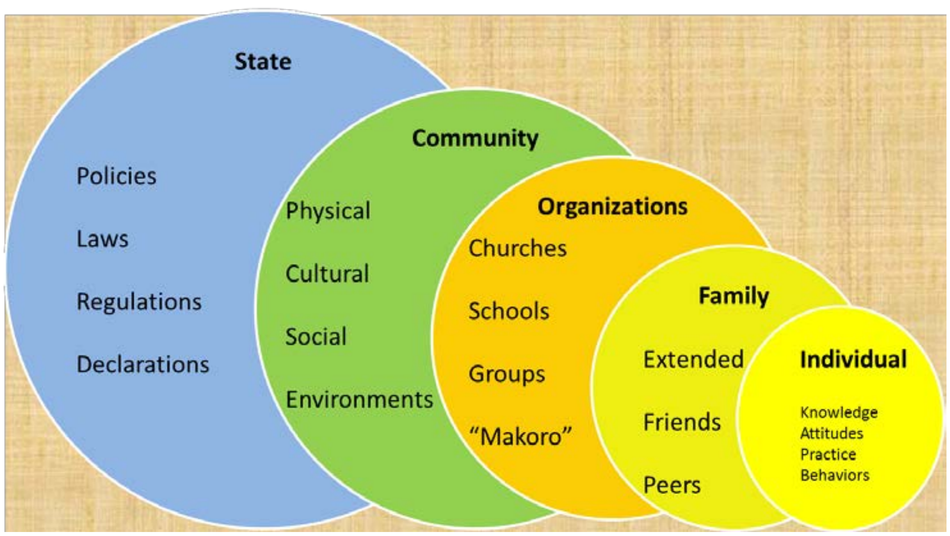

Figure 11. Social Ecological Model of Public Health in Kiribati.

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Most Kiribati individuals live with their extended family, which is an important feature of life in Kiribati (Bataua, 1985; GOK, 1999; Roman, 2013). Decisions are made as a family unit with the oldest members traditionally accepting the role of the decision makers for the family. As elders age, they are cared for by their children. As climate change tightens its grip, families are feeling the effects and beginning to question if migration is the answer.   Elders are being forced to choose where the family should continue to live, who should leave the country and who should stay, as well as how to retain Kiribati traditions, cultures and family composition. Climate change is forcing families to make difficult decisions, including how, when, and where to migrate. Skilled workers including trained nurses are choosing to migrate to countries that are in need of healthcare workers (Australian Government, 2006; Shaw, 2014). This program provides opportunities for an individual to migrate and a solid scource of income. Increased burdens are being placed on the individual to send money back to Kiribati to support the family, to adapting to different cultures and customs, as well as the mental anguish, feelings of isolation and stress from being separated from loved ones for long periods of time.   Programs like this can also drain the Kiribati healthcare system of vital human resources that are needed to care for a growing population. In a country where nurses comprise almost 70% of the health system workforce and that averages less than 0.4 doctors per 1,000 people, maintaining trained health professionals is imperative to improve the health of the population (WHO and Ministry of Health and Medical Services, 2012).

Another example of an organization in Kiribati is a makoro[2]. A makoro is an organization of families. These groups can be religious based, but more often than not are comprised of families that live in the same neighborhood that work together for a variety of reasons, including to pool items for the needs of the group. The pooled resources contribute to the purchase of specific items including food for celebrations, building materials for a member's house, vehicles for income generation and transportation, solar lights for use at night, or video

[22] The makoro organization was observed during the author's time in Kiribati from 1998-2007.

equipment for entertainment. In Kiribati, makoro are targeted by other organizations to gather information for the development of new projects, to evaluate progress of activities or to inform regional or national reports. The flow of information can move from the organization being the influencer to the makoro being the influencer.

An example of health interventions targeted at the makoro or organization level of the socioecological framework, is when staff from an organization meet with community members to demonstrate new agricultural techniques to introduce new salt-water resistant crops, the organization is influencing the health of a community. If staff from an organization travel to a makoro to assess the need for a rain water catchment system, the community is influencing the organization by providing the needed information. Either intervention would improve the health of the members by providing improved access to food or consumable water.

The “kaare”[3] system is similar to the makoro system, but is usually an agreement between individuals and not families, whereby all of the members, each taking his or her own turn, give the agreed upon item to one person at the same time, allowing for larger accumulations of that item. In Kiribati, individuals can kaare anything from pre-made thatch for housing, coconut toddy to make traditional foods, or weaving or building materials. On South Tarawa, many individuals choose to kaare money. Many times this provides the leverage to individuals who may be lacking the necessary collateral needed for a formal loan from a bank or other institution, by providing enough money to reinforce their house from king tides, to build an above ground garden, or to purchase a rain tank. While this is an individual level intervention, there is potential to impact many different levels of the social ecological framework in Kiribati,

[3]The kaare is a traditional system observe during the author’s stay in Kiribati from 1998-2006.

especially if the kaare items are being utilized to improve health at the organization level to benefit families and individuals.

Community is the next level of influence in the socio-ecological framework for Kiribati and inlcudes physical, cultural, and social environments. Aspects of community level influence include where roads are built and who has access to wells or rain tanks, as well as cultural beliefs and customs that influence relationships in Kiribati. For instance, in the traditional maneaba system of village life in Kiribati, men are seen as the decision makers (UNICEF, 2005). Women do not have a specific voice in the maneaba[4] system. Customary beliefs do not allow women to go walking alone, especially at night (Bataua, 1985). These aspects of community in Kiribati influence organizations, especially when and how they meet with women for trainings and other health or project related interventions. Organizations should meet with women during daylight hours and separately from men to ensure full participation and open dialougue.

One of the last levels of influence in Kiribati is the state through the policies, laws, regualtion and declarations it enacts and enforces. Laws impact the health of communities, organizations, families and individuals. Evacuation orders, mandatory vaccination schedules for school entry, or building codes are good examples of policies that the state can enact that can have a positive effect on communities, organizations, groups, families and individuals. However, the state may enact policies that are contradictory to cultural beliefs, and the effects can be positive or negative on an individual's health depending on enforcement. A good example of this is the Special Fund (Waste Materials Recovery) Act 2004 which places a deposit fee on cans and plastic bottles that come into the country (GOK, 2004).

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[4] A maneaba is a traditional meeting house governed by a stringent set of cultural beliefs and rules.

A fee is placed on all cans and plastic bottles that enter the country. This fee is passed on to the consumer through an increase in the price of goods. Part of the money collected from the deposit is returned to consumers when they recycle the cans and bottles at collection centers around Tarawa. The remaining tax money is given to the company organizing the recyclables for transport to another country for further recycling. On Tarawa, enforcement of recycling is not a problem as there is motivation in the form of additional income for returning the cans and bottles to a recycling point. This policy has a positive effect on the communities of Tarawa. Unfortunately, there are no collection centers on outer islands, therefore there is no motivation to recycle them in these environments. Due to the unequal enforcement of the policy, residents must continue to pay the deposit and do not have the opportunity to regain their portion of the deposit money back.

While this paper focuses on five levels of influence in Kiribati, it is vital to note that additional important layers of influence lie outside Kiribati. Those are global and regional systems and policy, which significantly influence change in Kiribati. In the context of climate change, the collective actions or non-actions of others across the globe have an effect on the lives of people in Kiribati. Legally binding international conventions and regional frameworks influence state level policy, which in turn can impact the health of communities, organizations and families when they are implemented. A negative impact on Kiribati can occur through not adopting or integrating international or regional conventions and frameworks into national policy. An example of this is the limiting of aggregate greenhouse gas emmissions outlined in the UNFCCC Paris Agreement previously discussed in Chapter One (UNFCC, 2015). If the US government overturns its commitment to the Paris Agreement to reduce carbon emissions, opting to return to the reliance on fossil fuels, like coal and natural gases, countries similar to Kiribati will see the negative impacts manifest through increasing king tides, hotter land and ocean temperatures and an increased number of extreme weather events.

3.3 CLIMATE CHANGE AND HEALTH

Figure 12 shows annual rainfall captured at monitoring stations in Tarawa from 1926 – 2014. Peaks in annual rainfall, such as those shown in Figure 12 for the years 1993 and 2002, coincide with El Niño weather patterns. El Niño weather patterns are more closely aligned with additional rain, cooler temperatures, and higher sea levels due to the convergence of atmospheric water over Kiribati and the Northern Pacific Region. La Niña weather patterns are associated with dryer weather, warmer temperatures, longer periods between rainfalls, and drought. During times of drought in Kiribati, households conserve limited fresh water for drinking and cooking, leaving less water available for bathing, washing and general sanitation. An analysis of the water supply and sanitation situation on South Tarawa confirmed that during a drought, households resort to unsafe storage practices and alternative water sources, with up to 23% of the population relying on their neighbor for water (ADB, 2014). A recent study by the ADB estimated that the economic burden of poor sanitation on the urban area of South Tarawa alone costs between USD$3.51 – 5.45 annually (ADB, 2014) [5].

[5] Reported as Australian Dollars $4.7 -$7.3 Million using a 1AUD = 0.75USD conversion rate.

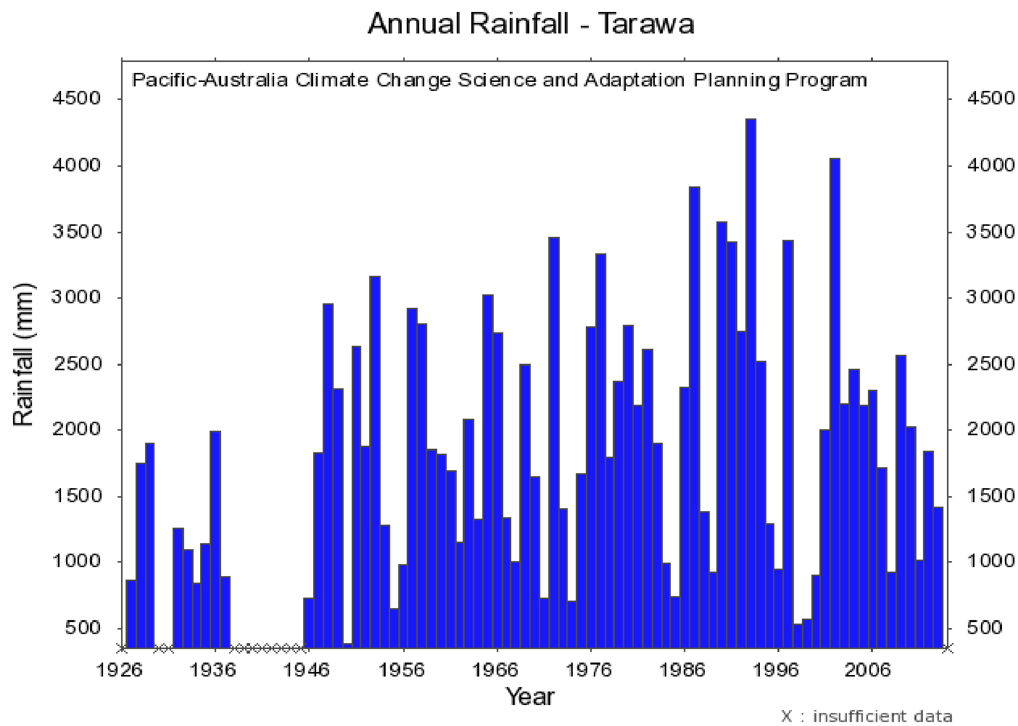

Figure 12. Annual Rainfall – Tarawa.

Reprinted from The Australian Government Bureau of Meteorology, by Pacific-Australia Climate Change Science and Adaptation Planning Program and the Kiribati Meteorological Service, 2016. Retrieved from http://www.bom.gov.au/cgi-bin/climate/pccsp/site_data.cgi?period=annual&variable=&nat_id=KIR&station=000002&ts_period=monthly . Copyright 2016 by The Commonwealth of Australia, Bureau of Meteorology. Reprinted under Creative Commons Attribution Australia License.

Kiribati has one of the region's highest under-five child mortality rates, which is estimated at 47 deaths per 1,000 live births, largely as a result of limited access to drinking water and poor sanitation (WHO, 2015). Figure 13 shows annual mean surface temperatures from the Pacific Region from 1961-1990. The graph shows that temperatures are increasing. One report suggests the possibility each degree of warming in Kiribati, leads to 1.9 to 5 % increase in hospitalizations from diarrhea (UNICEF, 2011). Longer periods of drought will limit the availability of fresh water which leads to poor sanitation. Poor sanitation in Kiribati is a driver for increased rates of diarrhea.

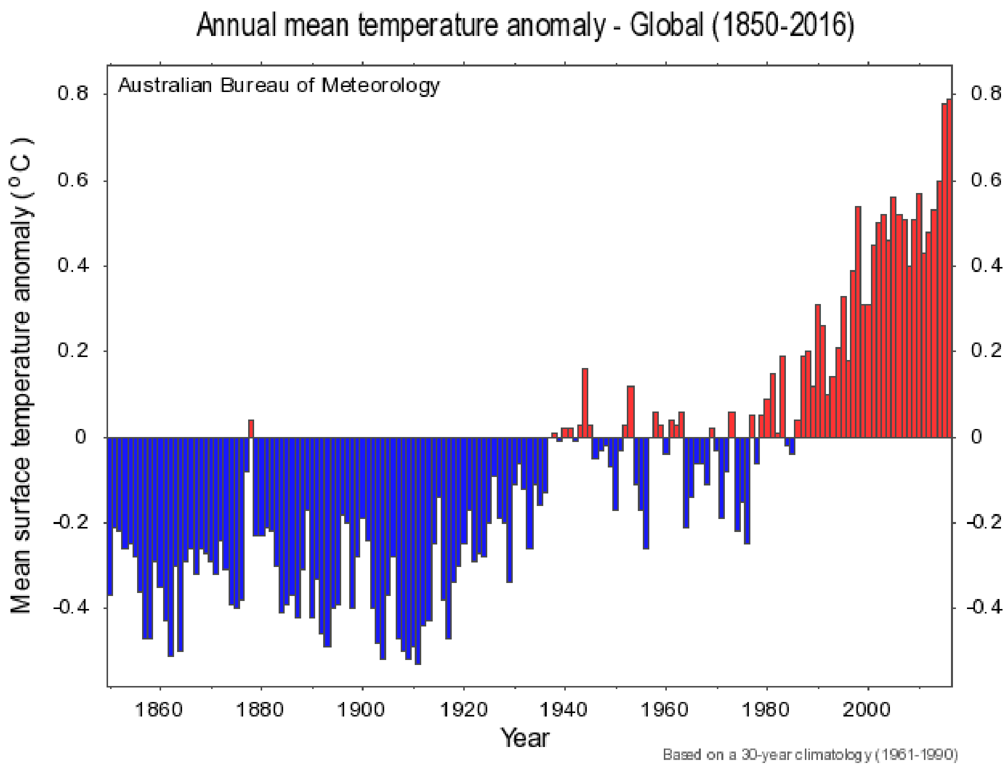

Figure 13. Global Annual Mean Temperature Anomaly from (1850 – 1990).

Australian Government, by The Bureau of Meteorology. 2011. Retrieved from **http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=global-timeseries** . Copyright 2017 by Australian Bureau of Meteorology. Reprinted under Creative Common Attribution Australia License. Data Source: Climate Research Unit HadCRUT4 global gridded (5x5 degree resolution) temperature data set through (Morice et al., 2012).

High tides and low tides exist due to the gravitational pull of the Earth to the moon, and to a minimal extent to the sun. This causes ocean waters to be drawn to coasts worldwide. The combination of weather driven patterns and astronomical forces can cause significant variability with tidal patterns. Sea-level pressure is a measure of atmospheric pressure, the weight of the air above and the force of that weight at sea-level. Atmospheric pressure is influenced by the winds speeds, air and sea temperatures. The higher the annual mean, the stronger the trade winds and drier the La Niña conditions. When mean pressure levels are low, this corresponds to wetter El Niño conditions. Data from the Pacific Climate Change Science Program, an Australian Government funded and hosted program, shows the annual mean sea-level pressure in Tarawa from 1947 to 2009 depicted in Figure 14. Mean sea-level pressure has been steadily rising since the 1940s (Australian Government Bureau of Meteorology, 2017). Kiribati's climate is variable due to its dependency on the location of La Niña and El Niño, however, many models predict that Kiribati will experience more extreme heat events and heavier rainfall (Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organization, 2011; Australian Government Bureau of Meteorology, 2017). This is consistent with the information shown in Figures 13 and 14.

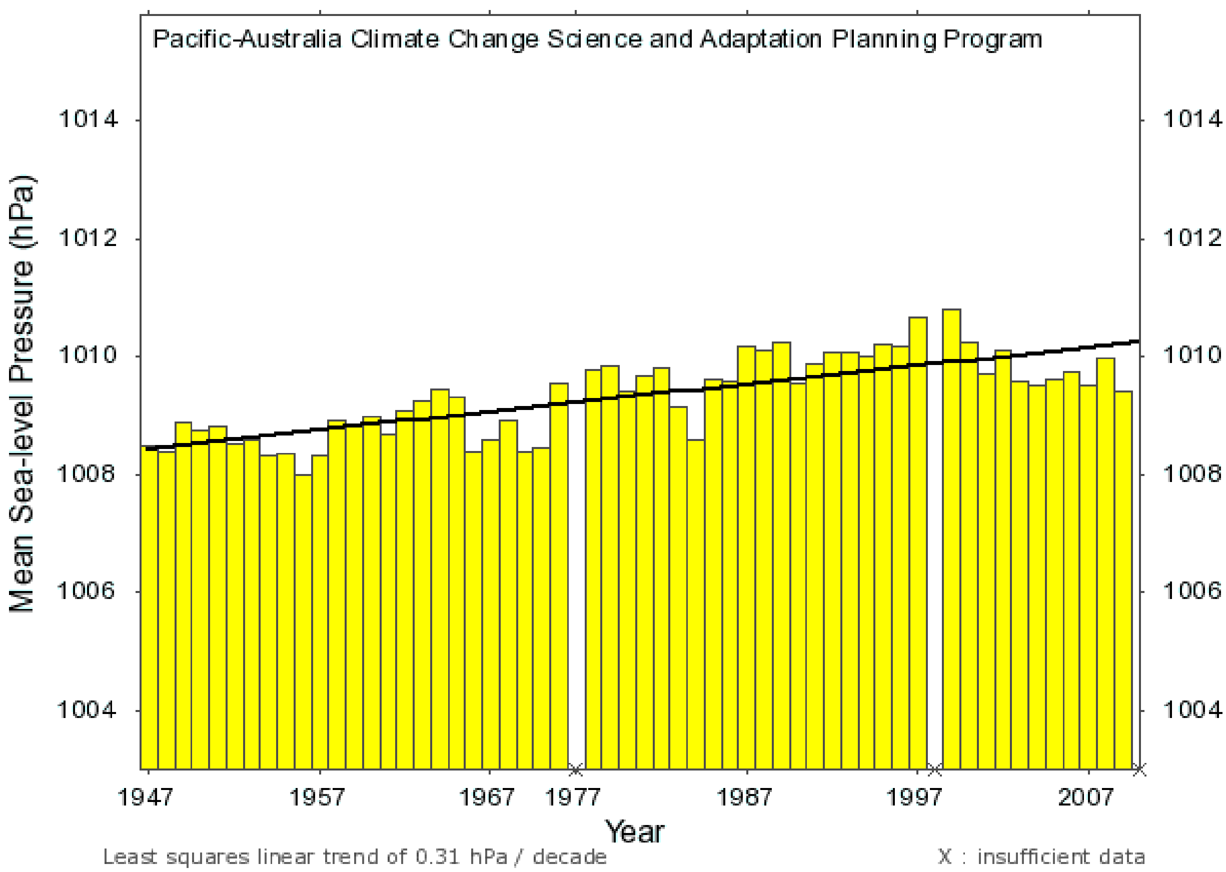

Figure 14. Annual Mean Sea-level Pressure – Tarawa.

The Australian Government Bureau of Meteorology, by Pacific-Australia Climate Change Science and Adaptation Planning Program and the Kiribati Meteorological Service, 2016, Retrieved on April 14, 2017 from **http://www.bom.gov.au/cgi-bin/climate/pccsp/site_data.cgi?period=annual&variable=&nat_id=KIR&station=000002&ts_period=monthly** .

Historically occurring only once or twice a year, a higher than normal tidal influx period, known as a perigean spring tide or king tide, occurs when the sun, moon and Earth are in alignment, causing extreme highs and lows of the tides. Recently, "king tides" has become the colloquial phrasing for any tide that is higher than normal. Following normal tidal patterns, king tides build over the course of several days to the highest peak tide and then slowly wane to normal fluctuation. King tide waves repeatedly strike coastlines for several days before returning to average tidal heights, leaving very little time for repairs, relocation or recovery. If damages happen during the early days of the build to peak heights, there is very little time to mitigate further damage until tides return to normal heights. Fresh water on an atoll is limited to the thin layer of fresh water that balances on top of the brackish water in the underground tables.

When a king tide pushes onto the land, causing coastal flooding, the porous land becomes saturated with high salinity ocean or lagoon waters. The water then begins to form large puddles or pools on land, effectively rendering the soil underneath these puddles useless for agricultural purposes. King tide events are happening in Kiribati with more intensity and frequency. Figure 15 shows how a king tide storm surge event in 2006 washed over the only road connecting the string of islets that comprise Tarawa and have begun pooling. When these pools of water are absorbed by the land and trickle through the porous coral sand, the salty water eventually reaches the water table. This upsets the delicate balance of the fresh water layer, churning it into a salinic and brackish mix, inhibiting the use of the fresh water from the underground lens and impacting the health of the residents on this source of water for survival. Although flooding and pooling of water occur during long periods of rain as well as during storm surges, rain encourages growth of vegetation and life of an island and contributes to the replenishment of the fresh water lens. High salinity ocean and lagoon waters from surges do none of these things.

Figure 15. King Tides Washing Over a Road, Tarawa, Kiribati

Photo Credit: Laura Werner, 2006. Printed with permission.

Families whose houses lie closer to the water and level to the ground are at higher risk for property destruction due to the inundation of salt water from storm surge and king tide flooding than those families that liver farther inland. Seawalls are the most popular form of mitigation of these disastrous effects, but with the intensity of the waves that come in repeatedly monthly, money for maintenance is continually needed and not always available, and can increase coastal erosion if not built properly. This impacts families' budgets, leaving less money each week for other expenses including food. Figure 16 shows how a king tide event in 2006 destroyed a seawall which crumbled during the surges and inundated familial land. Figure 17 shows the seawater inundation of land that was protected by a seawall, until king tide waves destroyed it. The trees can no longer live on the once protected land and have begun to die. Coconut tree trunks have begun to turn black and root systems have started to collapse as the land washes away.

Figure 16. King Tides Washing Over a Seawall, Lagoon Side, Tarawa, Kiribati

Photo Credit: Laura Werner, 2006. Printed with permission

Figure 17. Broken Seawalls and Storm Surge Inundating Land, Tarawa, Kiribati

Photo Credit Laura Werner, 2006. Printed with permission.

Large storms and high winds are particularly concerning during an El Niño weather pattern near Kiribati. When warmer temperatures of an El Niño weather event cause more atmospheric water to converge in an area, this can lead to higher king tides (Donner, 2012). The graph in Figure 18 shows tidal flow data provided by the Australian Bureau of Meteorology and plots monthly sea levels from 1993-2016 (Australian Government Bureau of Meteorology, 2016). The year 2001 was the first time that the maximum sea levels rose above 2.5 meters (approximately 9.84 Feet). Peak high tides have since surpassed this level at least four times since 2001 and coincide with El Niño weather patterns.

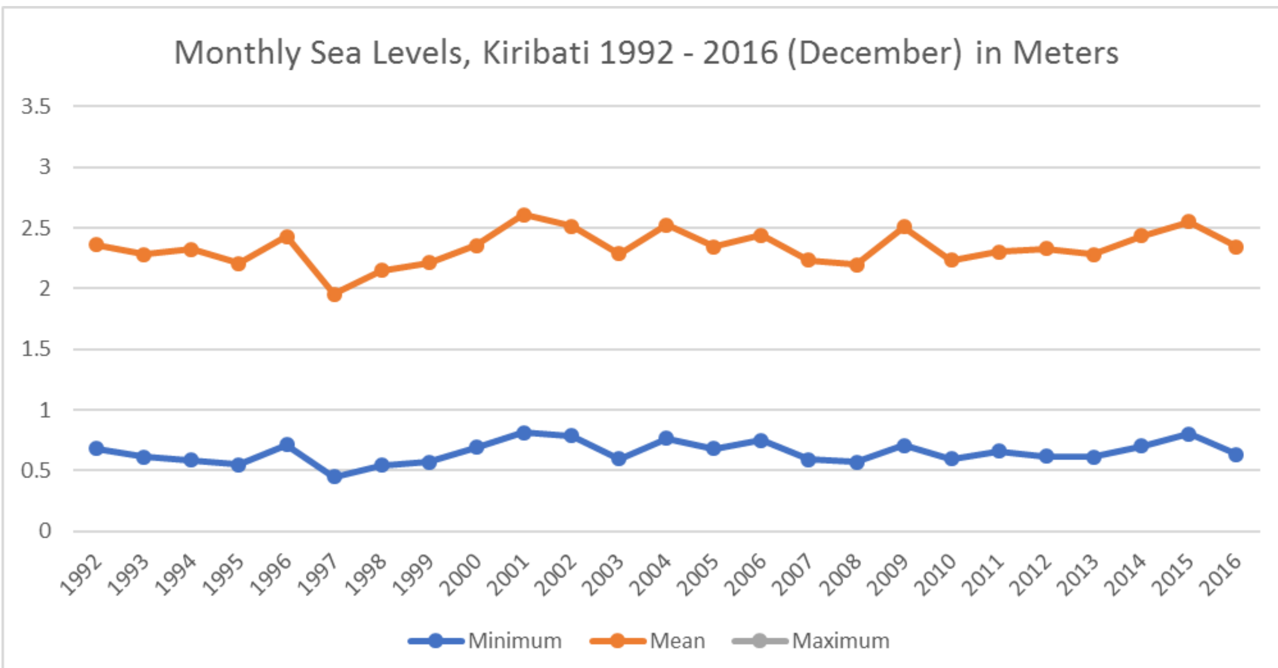

Figure 18. Monthly Sea Levels, Kiribati.

Data Source: The Australian Government Bureau of Meteorology, by Pacific-Australia Sea Level Monitoring Project, Monthly Sea Level and Meteorological and the Kiribati Meteorological Service, 2017, Retrieved on April 14, 2017 from **http://www.bom.gov.au/ntc/IDO70060/IDO70060SLD.shtml**

Figures 19 shows the slow tidal build to a peak king tide event from 13-21 July 2016 (Meteo365.com, 2016, July 13). Tide is the highest at 6.8 feet and is the lowest at 0.05 feet above sea level. Figure 20 shows high tides from 17 -25 July 2016, and how the tides continue to cause devastation as they slowly return to lower levels (Meteo365.com, 2016, July 17). According to Tide-forecast, "the largest known tidal rage at Tarawa, Gilbert Islands [Kiribati] is 7.7 feet" (Meteo365.com, 2017). Each time tides build, seawater inundates the land, causing flooding and devastation to vital resources. Climate-induced king tides can be between seven to nine feet above sea level at their peak (Australian Government, 2016). The highest point on South Tarawa is from six to 13 feet above sea level (ADB, 2014). Moving to higher ground or further inland to avoid the tidal waters is simply not an option for many of the people living on these thin strips of land. Further complicating the available land to evacuate to is global sea-level rise, which is estimated to be 3.9mm per year (Aung, 2009).

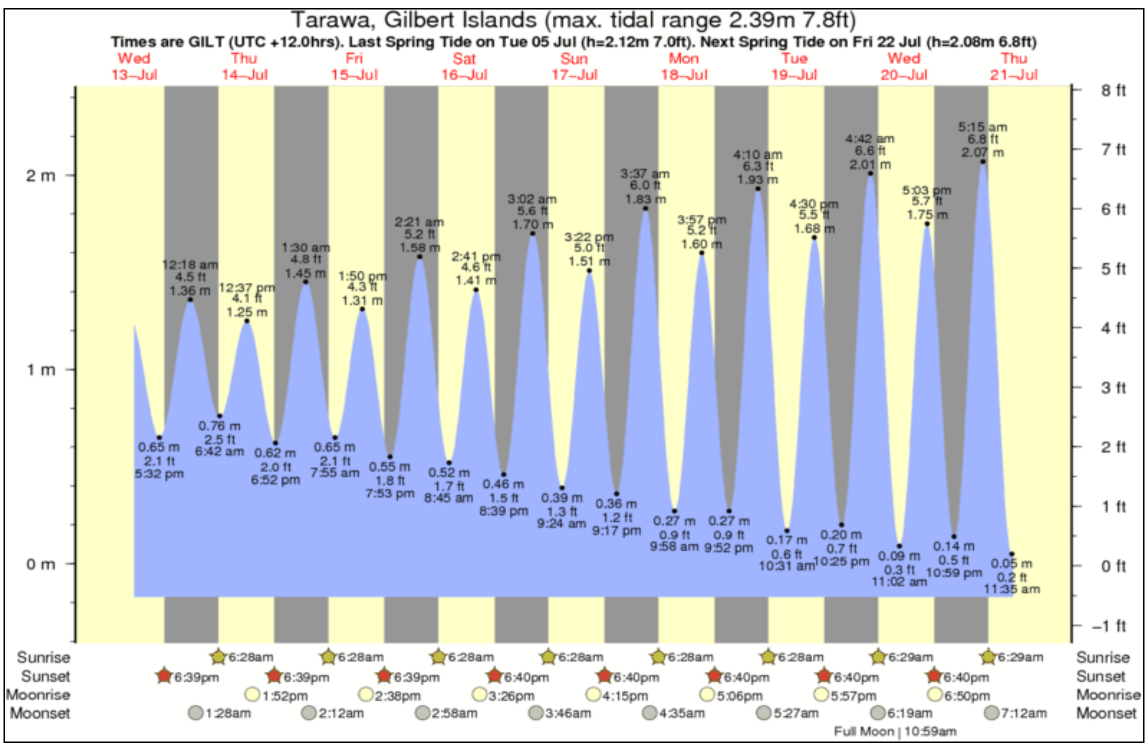

Figure 19. Tarawa Tidal Charts 13 July - 21 July 2016.

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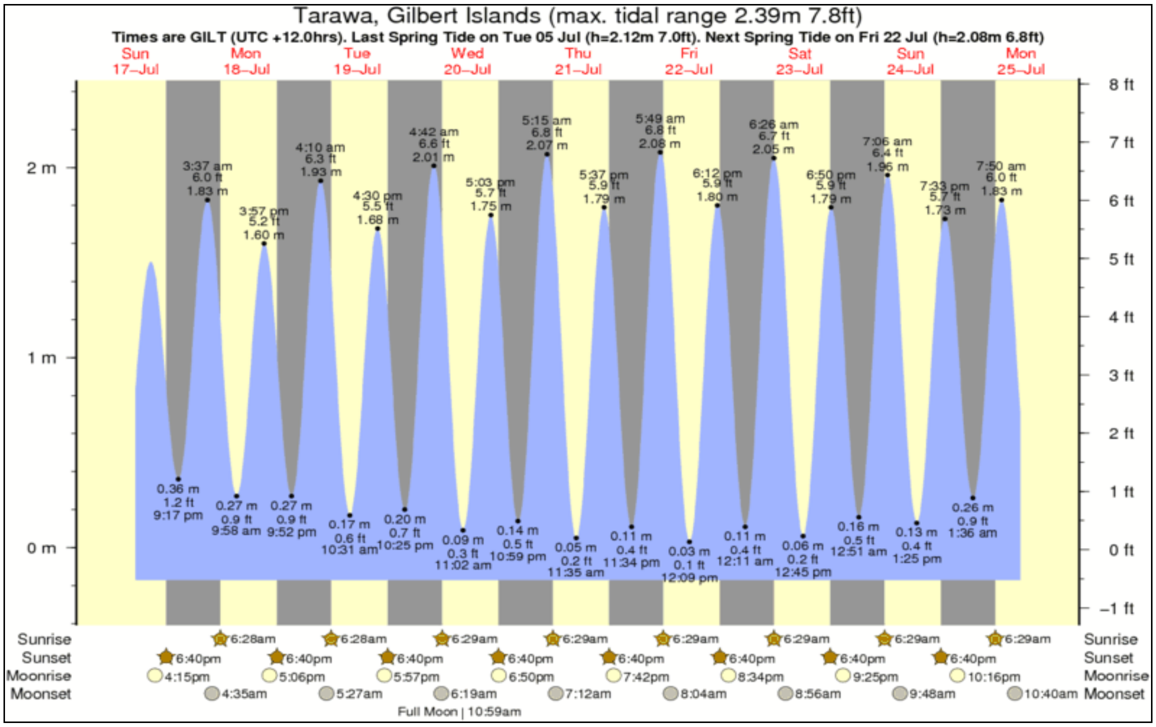

Figure 20. Tarawa Tidal Charts, 17-25 July 2016.

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Storms and cyclones occurring in ocean waters surrounding Kiribati combined with high winds can push tides farther inland and lead to seawater inundation of coastal and low lying areas, a phenomenon known as storm surges, leaving entire islands at risk of flooding (GOK, 1999). The effects of storm surges and king tides happening at the same time are disastrous. Figure 21 shows a picture of flood waters pooling on a low-lying area of the island after a king tide event in 2006. This event coincided with a storm with high winds and heavy rains causing waves to surge onto the land. This storm caused damage to homes and roads, to which communities and the government quickly responded. In contrast, in 2015, three cyclones occurred simultaneously in the South Pacific Region, with Kiribati caught in the middle. This caused wave surges that destroyed houses and other infrastructure across several of the Gilbert Group of islands, including Tarawa. With ocean waves churning from the cyclonic activity, Kiribati also faced another king tide event. This event forced an international emergency response, damaged food and water sources, flooded a local hospital and forced the relocation of families as well as a maternity ward in the most densely populated part of Tarawa (IFRC, 2015; UNOCHA, 2016).

Figure 21. Storm Water Pooling on Land, Lagoon Side, Tarawa.

Photo Credit: L. Werner, 2006. Printed with permission.

Under optional circumstances, the end to any disaster is marked by the return to a previous or new state of normalcy. Recent experiences have shown that there is little to no time for the establishment of normalcy, new or old, to occur before another disaster, in the form of a king tide, strikes again. Timing between peak king tides in July of 2016 was only 17 short days (Meteo365.org, 2016). This leaves Kiribati in a constant state of emergency and requires the affected population to immediately and continually adapt to these changes. King tides threaten traditional and cultural practices and exacerbate poverty cycles. These monthly emergencies endanger basic elements of survival, including the availability of fresh water and food sources and loss of homes, and can be a source of significant and repeated psychological stress and trauma. The UNICEF (2011) stated that "Under increasing climate induced sea level rise, the occurrence of extreme tide events is projected to increase" (p.14).

As a country totally comprised of islands, Kiribati is surrounded by water, but in terms of fresh water for survival, it is limited. There is always either too much water during the rainy seasons, or increasingly, not enough to sustain populations, especially in urban areas, narrower parts of islands and smaller subsections of islands called islets. Consumable water is available in Kiribati through access to the underground fresh water lens that is between 1.5 – 2.5 meters below the ground surface (Falkland, 1992; GOK, 1999;). For an island to develop a fresh water lens, there would need to be a minimum island width of 300 meters (GOK, 1999; Marshall, 1995).

Adaptation to the impacts of climate change will be different in urban and rural contexts. There is a distinction between adaptation to climate change and the adaptation demands of a progressively urban area. Climate change acts as a multiplier of effects for the urbanization challenges of South Tarawa, where residents of the urban areas of South Tarawa and Kiritimati Island can pay for piped water from under water aquifers or for the delivery of de-salinated water to their residence for a flat fee each month (ADB, 2014). Demands for clean water, traditional foods and local materials are already in high demand. These services are unreliable and dependent on proper maintenance; often end users experience long gaps in service delivery due to a breakdown in the system including leaks or breaks in the piped lines, or lack of parts to repair equipment. The Government of Kiribati reported in its initial communication under the UNFCCC, "The sustainable yield estimate of the galleries [of underground water] supplying potable water in South Tarawa is about 1,300 cubic meters a day, which means that 26,000 persons can be supplied with water at 50 Liters per head per day…with leakage and use of water by institutions is sufficient for about 20,000 persons" (1999, p.11). The report confirms that this source of usable water will not be enough to sustain the population living on South Tarawa. (GOK, 1999).

The ground water on South Tarawa and lagoon waters near shorelines are highly contaminated with fecal coliforms (ADB, 2011). King tides push this contaminated water onto land and into wells, gardens and living areas, exacerbating the contamination of water and food sources with both salt and human waste. The Kiribati Government and the World Health Organization have advised residents to avoid utilizing ground water on several islands, inparticular on South Tarawa, due to fecal contamination levels (White, 2010; WHO, 2012).

Rainwater is one of the only viable sources of fresh water. Sealed concrete rain tanks that are decades old are still being utilized to collect consumable water. These tanks pose a hazard to the health of those who drink the collected water. Concrete is a porous material that can weaken over time, causing cracks and eventually breakage which allows bacteria to grow. Calcium carbonate can leach from the material. Ingestion of calcium carbonate can lead to headaches, diarrhea and vomiting when consumed in high quantities. Plastic rain tanks, designed specifically to withstand high temperatures, are the preferred method to collect and store large quantities of rain. These plastic tanks are expensive to purchase, transport and properly install and are shipped to Kiribati from Australia, New Zealand or Fiji and are not locally made. These tanks, as with all rain water catchment equipment, must be regularly cleaned and maintained. Failure to maintain or properly collect rain increases the risk of ingesting contaminated water. Contaminants include dirt, sand, leaves or even salt from evaporated sea spray. If the tanks are not maintained properly, they can also become breeding grounds for bacteria and mosquitos (Burton, 2011, United Nations Children Fund, 2011).

For families on South Tarawa who own land and have access to regular employment, purchasing a rain tank is not difficult. Loan schemes are available through urban banks and housing corporations for those who have the collateral. However, for families with increased vulnerabilities in relation to adapting to the impacts of climate change including diminished access to land, contaminated, salty, or brackish wells, limited access to employment or other income generating activities, the cost is prohibitive. Individuals are forced to spend limited resources on purchasing water, steal water from unlocked tanks when the owners are not home or vandalize fencing and locks to gain access to rainwater. Families located on rural outer islands, where additional shipping costs increase the farther one travels from South Tarawa, are even less likely to own or have access to a large rain tank.

The traditional diet of I-Kiribati[6] consisted of foods that come from the sea, in particular fish, lobsters, octopus, sea worms, crabs and shellfish. Other common traditional foods include coconuts, swamp taro, papaya, banana, pork, chicken and pandanus[7]. Several types of shellfish

[6] I-Kiribati is a traditional phrase referring to the people originating from Kiribati

[7] A fruit from the tree often referred to as a screw pine.

can be collected from the lagoons of islands that have large reefs; varieties include nouo, koikoi, bun, katura, koumara, ninikatona, ninimwakaka, and kabwan (Ambo, 2016). Shellfish are an important source of protein for those living in urban areas and are also a significant source of income for families who sell bags of their collections in markets and on the side of the roads (Thomas, 2006; Government of Kriibati, 1999). Recent years have seen a decline in the availability of some types of shellfish from the reef, forcing individuals to spend more time on the reef collecting the shellfish needed to supplement their diets and incomes.

Contamination and high bacteria counts of the lagoon waters of South Tarawa are well documented with a noticeable increase in diarrheal diseases and ciguatera poisoning (ADB, 2011; Butcher-Gollach, 2012; Katz, 2014). Many islanders have endemic levels of harmful bacteria within their bodies, and the long-term effects of harboring harmful bacteria over time can be detrimental to one's health. The Ministry of Health has issued warnings against eating shellfish that come from polluted waters (WHO and Ministry of Health and Medical Services, 2012). Many individuals cannot afford other options and continue to eat contaminated shellfish. This poses a significant public health risk for an outbreak, including from pathogens including those for Hepatitis A, typhoid, cholera and many other bacteria and viruses (Potasman et al., 2002).

The reported cases of diarrhea and dysentery have increased significantly in recent years. Ministry of Health and Medical Services in Kiribati reported over 25,000 cases in 2012, and in 2010 only 10,000. Minor outbreaks from various organisms occur on average three times a year (ADB, 2014). A recent outbreak in 2013 of rotavirus resulted in 1,118 reported cases, 103 hospitalizations and six deaths (Tabunga, 2014). The last outbreak of cholera was in 1977 - 1978 There were over 1,800 cases and 20 deaths (Government of Kiribati, 1999). If an outbreak of cholera were to happen on South Tarawa today, these numbers would be much larger due to crowded conditions, limited drinking-water access and poor sanitation. The rotavirus outbreak significantly strained the healthcare systems on South Tarawa. It would be even more challenging for the healthcare system to respond to an outbreak of a larger scale.

Being surrounded by the sea, I-Kiribati depend heavily on fish for protein. Ciguatera fish poisoning results when fish contaminated with ciguatoxins is consumed. Gastrointestinal, cardiac and neurologic symptoms are experienced, which can have lasting effects (Skinner, 2011). Ciguatera fish poisoning has increased since the early 1970s. Data presented in 1980 by Marriott and Dalley to the 12th Regional Technical Meeting on Fisheries sponsored by the South Pacific Commission showed only 456 total reported cases of ciguatera fish poisoning treated on Tarawa from 1974 – 1980 (pg 3). Total cases increased almost seven fold with reported cases from 1998 – 2008 totaling 3,183 (Skinner, 2011). This is consistent with data reported earlier in this paper, showing that as temperatures increase, so do the levels of ciuatera fish poisoning. Warm sea surface temperatures and frequent storm activity can exacerbate levels of ciguatera fish poisoning (Gingold, 2014).

Swamp Taro is another traditional food that is being affected by Kiribati's changing climate. It is a highly-prized delicacy of Kiribati and is featured in traditional functions and celebrations. Swamp Taro is a root crop that grows in large pits, dug directly into the water table. The taro pits vary in size and location. They can be in the bush or in close proximity to a family's living quarters. When king tide flood waters spill onto the land, the water can pool in the pits, destroying the crop and leaving stagnant pools of water for mosquitos to breed.

Mosquitos are abundant in Kiribati and while the nation has remained free from malaria, dengue, Zika and chikungunya outbreaks have been documented and are on the rise across the

Pacific Region (Roth, 2014). High numbers of travelers between and within neighboring countries, the mosquitos' intrinsic ability to adapt and spread, and climate change impacts of wetter and hotter environments contributes to the spread of the viruses to Kiribati. The first dengue outbreak Kiribati was reported 2008 and resulted in 837 cases (Cao-Lormeau, 2014; WHO, 2009). In February 2015, Kiribati reported an outbreak of chikungunya, an emerging disease not found in the Pacific Region before 2005, affecting the total populations of South Tarawa (43%) and Betio (57%), (Radio New Zealand, 2015). By Mid-April 2015, the virus had reached 13 outer islands, with two islands reporting more than 200 cases (Radio New Zealand, 2015).

Another emerging disease of concern is the mosquito-borne Zika virus. Though there have been no documented cases of Zika virus in Kiribati as of the writing of this paper, the WHO and the CDC have both stated that they expect the virus to spread (CDC, 2016; Lucey, 2016; WHO, 2016). There are approximately 2,000 births each year in Kiribati (WHO and Ministry of Health and Medical Services, 2012). The dangers of a pregnant woman being bitten by an infected mosquito, contracting, and passing the virus onto the baby congenitally are real. Zika virus contracted congenitally during the first trimester of pregnancy has been associated with cases of microcephaly, being born with a smaller than normal head, of over 2,400 infants (Martines, 2016). Microcephaly, like many other conditions that compromise the neurological system, is associated with delayed learning and other cognitive disabilities. Kiribati has limited technical abilities and resources to respond to a large cohort of disabled children, especially on the outer islands. There is one school for disabled children, catering to families located on South Tarawa only, which historically has received limited support from the government and other agencies. In addition to mosquito-borne transmission of Zika, there is particular concern for pregnant women to contract the virus through sex with an infected partner (CDC, 2016; Oster AM, 2016). While it is customary for women and young children to sleep under large family mosquito nets at night, fathers and young men many times do not sleep with nets, particularly during special events and holidays.

Though the infant mortality rate has improved over the past decades due to increased programming and awareness, Kiribati has one of the Pacific Region's highest at 47% (UNICEF, 2013). For many islands, there is only one road between houses and a health clinic. King tides can cut off access to roads and the destructive damage caused by successive flooding. The UNICEF estimates that 42% of all births happen in isolated rural outer islands and that 50% of all births are considered high risk (UNICEF, 2013). High risk births should take place in a health center facility with a trained attendant. If king tides were to block access to a health center facility for a woman with a high-risk pregnancy, it could have negative outcomes for the infant and the mother. During Cyclone Pam in 2015, large portions of the main causeway connecting the most densely populated islet of Betio to the remaining islets forming South Tarawa, and the main hospital, were destroyed. The only maternity ward of Betio Islet was flooded due to the combination of king tides and storm surges, placing both mother and infant lives in damger (IFRC, 2015; USAID, 2015).

4.0 WAYS FORWARD FOR I-KIRIBATI

4.1 RECOMMENDATIONS BASED ON THE SOCIAL ECOLOGICAL FRAMEWORK

No one country can single-handedly prevent climate change from happening. In the case of Kiribati and other low-lying countries, migration will need to happen. Kiribati has already established migration plans, which include concepts like ‘migrating with dignity,’ which encourages investments in education, skills and trades to assist those who choose to migrate to integrate into a different society (Government of Kiribati, 2012). Equipping individuals with the skills, knowledge and power to adapt to imminent changes will strengthen resiliency through change and improve overall health. By highlighting the ways in which climate change is impacting the daily lives of individuals, we begin to understand the need for adaptation to be promoted through the levels of influence to all levels of society, especially for extremely vulnerable populations, including the disabled, young children, women and the elderly. Using the social ecological model for Kiribati to inform adaptation policies, projects and plans, we can bring about positive changes in the health of the people most affected. This will require a systematic shift in the way adaptation is currently being approached. The new approach will need to be more person-driven and rights based.

The changes in Kiribati’s climate have great impacts on the daily lives of the I-Kiribati. Growing food, catching fish, collecting drinking-water, transportation between islands, increased flooding and much more. Despite the Kiribati Government’s struggles in accessing available global climate change funds, adaptation to climate change is occurring. To move beyond current adaptation approaches which largely focus on infrastructure, there needs to be a shift in focus to address how Kiribati communities are adapting to the changes in their climate.

Research on safe and sustainable shellfish farming as well as low cost cleaning and proper cooking practices for the shellfish focusing on decreasing the levels of harmful bacteria before consumption would provide a person-centered approach to sustaining this valuable food source. By eating shellfish that has been properly cleaned through such a procedure, the potential for an infectious disease outbreak is minimized. Clean shellfish farming practices could potentially provide an additional source of income for individuals.

Agricultural practices will need to be restructured and adapted to mitigate any negative impacts to health from climate change. There is a need to explore opportunities for above ground planting of drought resistant taro varieties, including small container gardens that could be relocated to higher ground when king tide flooding occurs. Agricultural techniques that explore ways to preserve traditional farming practices for crops such as the swamp taro needs to be researched. One example would be to reuse rain tanks that can no longer be repaired, but are large enough to support the cultivation of swamp taro. Vertical or hanging gardens should also be explored and would maximize space in overcrowded areas of South Tarawa and Betio. Container gardening has been successfully introduced for other crops on South Tarawa through a development assistance program[8]. Building tall, above-ground, non-penetrable pits, where taro could potentially be cultivated and protected from king tide flood water inundation is another option to preserve traditional practices, the cultural significance and sustainability of this important food. These pits could also be utilized for other important crops, like bananas, papayas, and local greens that could supplement vitamin and mineral deficient diets and serve as a method of income generation for families. Hydroponics could also provide an income generation option that would not be dependent on the soil, but could only be an option if enough fresh water was available.

Along with water tank cleaning and maintenance awareness, low cost options for the storage of rainwater should be made available to rural individuals and families from urban areas with low incomes. adaptation approaches could include increasing the availability of smaller rain tanks, and portable, stackable and easily washed containers. Plastic sheeting can be utilized to replace expensive corrugated iron and guttering systems. Capitalizing on the traditional makoro or kare systems to purchase rain water harvesting equipment would impact the health of those who participate in the system, by providing them with the funds to make larger purchases.

Providing large community rain tanks for public access is traditionally done for modernized community meeting houses on outer islands. The water is then reserved for traditional functions, sick individuals or visitors. This practice should be encouraged for neighborhood groups in both urban and rural areas of Kiribati, which could offset the cost for families that cannot afford a large rain tank on their own. This would improve health equity by increasing access and availability of fresh water to families in need. Research on alternative low-

[8] These programs were known to operate during the author's time of living in Kiribati from 1998-2006.

cost methods for purifying, desalinating and storing clean water should be explored. Adaptation methods should focus on decreasing the divide between those who have access to fresh water and those that do not. Disregarding the inequitable distribution of and access to fresh water with such an important and limited resource could potentially unravel this peaceful nation, sending it into conflict (Government of Kiribati, 2009; White, 2010).

The spread of vector-borne diseases in Kiribati such as dengue, chikungunya and Zika, will increase as the climate continues to change. Focusing on the importance of utilizing mosquito nets and eliminating mosquito breeding sites are valuable person-centered adaptation measures that have the potential to increase health outcomes. Pre-filling areas of islands that are prone to water pooling from king tides, storm surges or excessive rain, such as old swamp taro pits could potentially minimize absorption of high saline water into the ground water and limit potential mosquito breeding grounds.

In Kiribati, women, traditionally tasked with child-rearing duties, typically have more access to health services than do men. Therefore, additional Zika awareness targeted towards sexually active men and young boys, especially seafareres would be needed. Women, especially pregnant women, need additional screening, and testing for awareness of the importance of contracting Zika during pregnancy either through the bite of a mosquito or through sexual intercourse with an infected partner. If Zika was to be discovered in Kiribati, a woman who was pregnant and who lives in the vacinity of a swamp taro or banana pit, breeding grounds for mosquitos, should take extra precautions to avoid being bitten. These precautions include relocating to a safer location for the duration of the pregancy to decrease her risk of being bitten by an infected mosquito. Stregthening the capacity of the Kiribati School for the Disabled to include children from the outer isalnds and for those with decreased cognitive abilities, particularly those specific to microencephaly, would be preparation for climate change adaptation.

Island medical staff will need to be more aware of when king tides are expected and if possible identify a plan to attend to a mother in an isolated environment, especially in areas where air strips and roads are easily impacted by king tide flooding and storm surges. Examples to avoid challenges presented by a king tide include having the family, as is practice, come to stay at the nursing station earlier than expected in the last stages of pregnancy; working in conjunction with a trained and properly equipped local midwife; or having the pregnant mother relocate to an extended family member's house close to the expected time of birth, in order to be nearer to the clinic when time for her birth comes. This will ensure a safe delivery and that important vaccines, post natal and newborn care are delivered in a timely manner.

The money utilized to create seawalls may be better used to identify engineering adaptations for houses to be able to withstand wave impacts or king tides, storm surges or high winds. Engineering trenches where flood waters from king tides are allowed to pool and then eventually returned to the lagoon or ocean via pipe or gravity could prevent individual homes from excessive damage due to flooding. Traditional houses, called "buia," were built on stilts and made of local materials including coconut or pandanus trees. These traditional houses are cooler than houses utilizing imported materials such as concrete and corrugated iron roofs. Local materials allow for ocean breezes to enter and provide shade from the hot sun. Imported materials tend to trap heat and block breezes making them much hotter, especially during the high sun parts of the day. Those wanting to put up structures near shore lines should be encouraged to reinstate traditional styles of building. Adapting the heights of the floors of houses to avoid flooding or alternatively, lining the edges of houses with impervious materials to prevent king tide waves from entering the houses could potentially decrease loss of personal belongings and other damages. Raising house foundations to withstand the constant inundations will be costly, and very few families in Kiribati, especially on South Tarawa, would be able to afford such an adaptive measure without financial assistance.

5.0 CALL TO ACTION

Climate change has become one of the most talked about issues of all time, championed by celebrities, debated in national elections, and discussed on global agendas, and for good reason. Changes in the global climate will impact everyone, male female, young or old, rich or poor. These changes will not discriminate although different areas and individuals may feel the impacts differently. The impacts of even a slight change in weather in a particular region have the potential to impact lives for better or worse. Changes in climate are a historical fact. Climates will continue to change naturally. Industrial processes and global emissions have exacerbated these changes.

This paper began by defining climate change and discussing the policy framework that has contributed to the discourse on climate science. The paper then moved on to discuss some of the impacts of changing climates, most of which are human induced, including the rising levels of greenhouse gasses within the Earth's atmosphere. Three example of how greenhouse gasses are affecting our environments were given including: increased temperatures, the melting of glaciers, snow covers and ice caps; and rising sea-levels. The impacts that climate change is having on health were highlighted and include decreased food security, increased malnutrition, and adaptation of mosquitoes, vectors of emerging infectious diseases like dengue, chikungunya and ZIKA, to areas where they had previously not been observed. Impacts of climate change were highlighted by looking at the Pacific Region, one of the world's most vulnerable to climate change and significantly impacted on the fluctuations of La Niña and El Niño weather patterns, increasing extreme weather. The paper then used the example of the country of Kiribati, a low-lying coral atoll nation on the front-line of climate change. Impacts from climate change that Kiribati is observing are increased temperatures, extreme weather events and sea-level rise, including an increase in the number and height of king tides.

The potential for the people of Kiribati to continue life as normal has been shattered. In the context of climate change, the lives of the Kiribati people will continue to be influenced by the winds of change, both literally and figuratively. As demonstrated throughout this paper, the effects of climate change witnessed in Kiribati have affected the health of the nation's entire population, both young and old, men and women, placing over 100,000 people at risk of experiencing negative health outcomes. While this paper discusses several of the ways climate change is impacting the lives of the people of Kiribati, with a focus on king tide flooding and storm surges, it is not an exhaustive list. Droughts, increased surface and sea temperatures, ocean acidification and other human influences may impact lives differently than the areas examined in this paper.

Research for this paper focused on documents written in English only. No new data were collected for this paper and data availability, especially for sex-disaggregated data, in Kiribati as well as the Pacific Region is widely varied, which limited discussion in terms of the gendered impacts of climate change in the Pacific Region and in Kiribati. Research related to the impacts children are experiencing in relation to climate change in Kiribati has been conducted on a regional scale by UNICEF, but as the climate changes, so will the impacts they face. Climate change is not just affecting the lives of children. The lives of men and women of all ages will be impacted in different ways. Monitoring and documenting these changes as environments continue to be influenced by climate, particularly for health, will need to be continued, not just for children, but for all individuals of the I-Kiribati community. Continued research should focus on assessing the lives of women, men, families and community units and how they are adapting to climate change. Traditional skills and cultural practices that are disappearing as a result of the changes in the climate should be documented and other adaption approaches should be explored with urgency. The cultivating of swamp taro in Kiribati is one such example of a traditional skill.

There is no question that adaptation to the profound effects Kiribati is experiencing needs to occur. How adaptation should be structured to allow for the greatest impact on people's lives is a good beginning. When daily conditions improve, so do health outcomes. Working within a socio-ecological framework to promote adaptation to the changing climate will help to ensure effective change in the daily lives of the people of Kiribati. Sustainability of adaptation measures will increase if they are promoted across the different levels of influence.

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