



Calhoun: The NPS Institutional Archive
DSpace Repository

Theses and Dissertations

1. Thesis and Dissertation Collection, all items

2014-12

Climate change in Myanmar: impacts and adaptation

Slagle, John T.

Monterey, California: Naval Postgraduate School

<http://hdl.handle.net/10945/44672>

This publication is a work of the U.S. Government as defined in Title 17, United States Code, Section 101. Copyright protection is not available for this work in the United States.

Downloaded from NPS Archive: Calhoun



Calhoun is the Naval Postgraduate School's public access digital repository for research materials and institutional publications created by the NPS community. Calhoun is named for Professor of Mathematics Guy K. Calhoun, NPS's first appointed -- and published -- scholarly author.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

<http://www.nps.edu/library>



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**CLIMATE CHANGE IN MYANMAR: IMPACTS AND
ADAPTATION**

by

John T. Slagle

December 2014

Thesis Advisor:
Second Reader:

Michael S. Malley
Tristan J. Mabry

Approved for public release; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			<i>Form Approved OMB No. 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE December 2014	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE CLIMATE CHANGE IN MYANMAR: IMPACTS AND ADAPTATION			5. FUNDING NUMBERS	
6. AUTHOR(S) John T. Slagle				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB protocol number ____N/A____.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			12b. DISTRIBUTION CODE A	
13. ABSTRACT (maximum 200 words) Myanmar is a Least Developed Nation, according to the UN, and therefore is highly vulnerable to the negative effects of a changing climate. To assess the relationship between Myanmar and climate change, this thesis analyzes projected impacts on the nation and its people, the current state of adaptation, and how Myanmar's government has prepared. Projected impacts are viewed through the lens of the most recent IPCC reports and climate models, and discussed in relation to vulnerable areas in Burmese society and governance. This thesis concludes that Myanmar's environment, people and society are at a significant risk; higher temperatures, altered precipitation rates, and higher sea levels will lead to reduced agriculture output, the spread of disease, and loss of habitable land. Though recent governmental action has laid the framework for suitable adaptation measures, slow progress in past decades has left Myanmar highly vulnerable to the negative impacts of climate change. Myanmar's next election is scheduled for 2015, and the emerging leaders have the opportunity to make significant progress in climate change adaptation. Cooperation between Myanmar's new leaders and the international community could accelerate the nation's adaptation efforts and result in significant progress on climate change preparedness projects.				
14. SUBJECT TERMS Myanmar, Burma, climate change, climate adaptation, climate change mitigation, International Panel on Climate Change, State Law and Order Restoration Council, State Peace and Development Council, Southeast Asia			15. NUMBER OF PAGES 97	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU	

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited

CLIMATE CHANGE IN MYANMAR: IMPACTS AND ADAPTATION

John T. Slagle
Lieutenant Commander, United States Navy
B.A., Elon University, 2002

Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF ARTS IN SECURITY STUDIES
(FAR EAST, SOUTHEAST ASIA, AND THE PACIFIC)**

from the

**NAVAL POSTGRADUATE SCHOOL
December 2014**

Author: John T. Slagle

Approved by: Michael S. Malley
Thesis Advisor

Tristan J. Mabry
Second Reader

Mohammed Hafez
Chair, Department of National Security Affairs

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

Myanmar is a Least Developed Nation, according to the UN, and therefore is highly vulnerable to the negative effects of a changing climate. To assess the relationship between Myanmar and climate change, this thesis analyzes projected impacts on the nation and its people, the current state of adaptation, and how Myanmar's government has prepared. Projected impacts are viewed through the lens of the most recent IPCC reports and climate models, and discussed in relation to vulnerable areas in Burmese society and governance. This thesis concludes that Myanmar's environment, people and society are at a significant risk; higher temperatures, altered precipitation rates, and higher sea levels will lead to reduced agriculture output, the spread of disease, and loss of habitable land. Though recent governmental action has laid the framework for suitable adaptation measures, slow progress in past decades has left Myanmar highly vulnerable to the negative impacts of climate change. Myanmar's next election is scheduled for 2015, and the emerging leaders have the opportunity to make significant progress in climate change adaptation. Cooperation between Myanmar's new leaders and the international community could accelerate the nation's adaptation efforts and result in significant progress on climate change preparedness projects.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

I.	INTRODUCTION.....	1
A.	MAJOR RESEARCH QUESTION.....	1
B.	IMPORTANCE.....	2
C.	PROBLEMS AND HYPOTHESES	3
D.	LITERATURE REVIEW	6
E.	METHODS AND SOURCES.....	14
F.	THESIS OVERVIEW	15
II.	EFFECTS OF A CHANGING CLIMATE ON THE NATURAL ENVIRONMENT.....	17
A.	INTRODUCTION.....	17
B.	THE STUDY OF CLIMATE CHANGE	18
C.	PROJECTED EFFECT.....	20
1.	Temperature.....	20
2.	Precipitation	26
3.	Sea Level	29
4.	Second Order Effects.....	31
D.	CONCLUSION	33
III.	CLIMATE CHANGE EFFECTS ON THE PEOPLE OF MYANMAR.....	35
A.	INTRODUCTION.....	35
B.	AGRICULTURE.....	36
C.	PUBLIC HEALTH	41
D.	WATER	44
E.	COASTAL ZONE.....	47
F.	CONCLUSION	49
IV.	CLIMATE CHANGE ADAPTATION IN MYANMAR	51
A.	INTRODUCTION.....	51
B.	BACKGROUND	52
C.	POLICY EVOLUTION.....	53
D.	CURRENT STATE OF CLIMATE CHANGE ADAPTATION AND ENVIRONMENTAL LAW.....	62
1.	Environmental Conservation Law	63
2.	Environmental Impact Assessment	63
3.	National Adaptation Program of Action	64
4.	Project Funding.....	67
E.	CONCLUSION	68
V.	CONCLUSIONS AND IMPLICATIONS	69
A.	MYANMAR’S CHANGING CLIMATE	69
B.	VULNERABLE POPULATION	70
C.	ADAPTATION AND PREPAREDNESS	70
D.	FUTURE CONCERNS AND IMPLICATIONS.....	71

LIST OF REFERENCES	77
INITIAL DISTRIBUTION LIST	83

LIST OF FIGURES

Figure 1.	Map of Myanmar	4
Figure 2.	Temperature Trends in Myanmar Compared to the 1961–1990 Average	24
Figure 3.	Observed Temperature Changes in Myanmar	25
Figure 4.	IPCC Projections for Future Temperature and Sea Level Changes.....	30
Figure 5.	Myanmar’s Rice Activity by Year.....	39
Figure 6.	Myanmar’s NAPA: First Priority Sectors and Projects	67
Figure 7.	GHG Emissions and Removals in Myanmar: 2000.....	72

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BEWG	Burma Environmental Working Group
CIA	Central Intelligence Agency
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalent
EIA	environmental impact assessment
ENSO	El Nino southern oscillation
EPA	Environmental Protection Agency
GCM	general circulation model
GHG	greenhouse gas
GMS	greater Mekong subregion
INC	initial national communication
IPCC	International Panel on Climate Change
LDC	least developed country
LDCF	least developed country fund
MOECAP	Ministry of Environmental Conservation and Forestry
MOFA	Ministry of Foreign Affairs
NAPA	National Adaptation Program of Action
NCEA	National Commission for Environmental Affairs
NECC	National Environmental Conservation Committee
NSDS	National Sustainable Development Strategy
PRECIS	providing regional climates for impact studies
SLORC	State Law and Order Restoration Council
SPDC	State Peace and Development Council
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
UNEP	United Nations Environment Program

UNFCCC
WMO

United Nations Framework Convention on Climate Change
World Meteorological Organization

I. INTRODUCTION

A. MAJOR RESEARCH QUESTION

On May 1, 2008, Tropical Cyclone Nargis made an eastward turn in its path up the Bay of Bengal, devastating an unprepared Myanmar the following day. The category four cyclone led to the deaths of over 138,000 people and destroyed lands along Myanmar's coastline and Irrawaddy delta, making it among the 10 most destructive cyclones in recorded history. Coastal lands were flooded, and tidal surges inundated low lying areas including the nation's most populous city, Yangon.¹

The severe effects of the storm were compounded by the inept reaction from Myanmar's government at the time, the State Peace and Development Council (SPDC). This secretive military regime left international warnings unheeded, prevented the accurate counting of civilian deaths, and prevented aid workers from entering the country in the wake of the powerful storm. Already under pressure from human rights advocates and the target of international sanctions, the SPDC was unwilling to lose further credibility by displaying its inability to protect its citizens to the world community. This strategy backfired, however, and only led to increased criticism of an ineffectual government that would be out of power less than three years later.²

The events surrounding Cyclone Nargis give rise to three primary questions. First, how vulnerable is the nation of Myanmar to the effects of climate change, effects that include an increase in intensity of storms such as Nargis? Second, what does the degree of vulnerability mean to the Burmese people? And third, as a late developing country that has only recently emerged from decades of secretive military rule under regimes such as the SPDC, what laws and adaptation methods are in place, if any, to prepare the nation

¹ Chew-Hung Chang, "Preparedness and storm hazards in a global warming world: lessons from Southeast Asia," *Natural Hazards* 56 (March 2011): 677, doi: 10.1007/s11069-010-9581-y; International Panel on Climate Change [IPCC], *Climate Change 2013: The Physical Science Basis*, ed. T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (Cambridge and New York: Cambridge University Press, 2013), 1273.

² "Cyclone Nargis," Burma Center Prague, accessed May 6, 2014, <http://www.burma-center.org/en/burma/history/cyclone-nargis/>.

for the effects of a changing climate? Stated succinctly—how does climate change threaten security in Myanmar?

B. IMPORTANCE

According to Kreft and Eckstein, “People all over the world have to face the reality of climate variability...More than 530,000 people died as a direct result of almost 15,000 extreme weather events, and losses of more than USD 2.5 trillion (in purchasing power parity) occurred from 1993 to 2012 globally.”³ Furthermore, over 138,000 of those 530,000 lives lost, as previously mentioned, were the result of Cyclone Nargis in Myanmar. Because of this catastrophe, “Myanmar [along with Honduras and Haiti] has been identified as one of the most affected countries in this 20-year period [1993–2012].”⁴ The security of the Burmese population is clearly affected in a negative way by climate anomalies.

Though individual weather events cannot be attributed to climate change with any degree of certainty, the overwhelming consensus in the scientific community states that, allowing for regional variance, the general trend is toward an increase in the number and intensity of extreme weather events. Intensified cyclones, sea level rise, temperature increases, and rainfall variability are primary effects that are expected in the coming decades, with secondary effects that include altered agricultural growing seasons, decreases in sea and river fishery stock, and forced human migration.⁵

The disruptive nature of a changing climate impacts all of a nation’s citizens. These impacts are compounded in a country such as Myanmar that has a poor, agrarian, and ethnically and religiously heterogeneous population that also has a history of domestic conflict. As an extremely late developing nation, these intensified negative impacts have the potential to exacerbate tensions among ethnic and religious groups and

³ Sonke Kreft and David Eckstein, “Global Climate Risk Index 2014,” Germanwatch, November 2013, <http://www.germanwatch.org/en/cr>.

⁴ Ibid.

⁵ IPCC, *Climate Change 2013: The Physical Science Basis*, 20–26.

to leave behind the most vulnerable sectors of the population such as the extremely poor, sick, young, and elderly.

C. PROBLEMS AND HYPOTHESES

Myanmar's security in the face of climate change depends on three specific factors. First is the vulnerability of the nation to primary effects to the natural environment. This includes changes to the sea level, changes in temperature norms, and to precipitation rates and predictability. The resulting impact on human activity is the second factor. Climatic changes will affect agriculture production, habitability of low-lying and coastal areas, the availability of potable water, and the prevalence and spread of vector-borne disease. The third factor affecting Myanmar's security in a changing climate is action by the government and society. Political and economic adaptation and the enactment of climate-resistant policies are essential in promoting security as the climate changes. These three specific factors will be discussed below.

Primary effects of climate change negatively affect the natural environment. In the certain areas of Myanmar, this means coastal inundation and flooding of river and delta regions due to rising sea levels and extreme precipitation events (see Figure 1). In the central dry area and hilly areas, this means longer droughts and higher incidents of wildfires from the combination of higher temperatures and lower rainfall. These events, along with rising ocean acidification and other changes to the natural environment, can lead to loss of biodiversity as plant and animal life struggle to adjust to climatic alterations. Regional changes are likely to have major impacts on Myanmar as well, as changes to the level, temperature, and pH balance of the Indian Ocean and Bay of Bengal reach Myanmar's vast coastline, and as shrinking mountain glaciers in the Himalayas affect water supplies of the Irrawaddy and other rivers that support the natural environment.



Figure 1. Map of Myanmar⁶

⁶ “Union of Myanmar Agricultural Atlas,” Food and Agriculture Organization of the United Nations, accessed December 5, 2014, http://dwms.fao.org/atlas/myanmar/downloads/atlas/p013_political_map.pdf.

The security of the Burmese people will be affected by complications related directly to the primary effects listed above. As an overwhelmingly agrarian nation, the stability and predictability of rice growing seasons are essential for people's livelihoods on an individual scale, and for economic growth and development on a national scale. Altered growing seasons due to changes in rainfall patterns, intensified variations in wet and dry seasons, and increased overall temperatures have the ability to threaten agricultural production. Forced human migration can also threaten the nation's stability. With a large percentage of citizens living in coastal regions and low lying river deltas, coastal inundation from a rising sea level, storms, and tidal surges can lead to the loss of homes and even entire villages. One such low lying coastal area is Rakhine State, home to a large Muslim population and an area of high rates of ethnic-religious violence. Forced migration from Rakhine State has the potential to ignite further violence as the minority Muslims are pushed east into majority Buddhist areas, or west into Bangladesh, a country that is also extremely vulnerable to climate-security issues and that has preexisting disputes with Myanmar regarding illegal human transit. Finally, health issues brought on by climate change can negatively impact Myanmar's security. Vector-borne illnesses such as malaria are likely to become more prevalent and freshwater availability will decrease with an increased average temperature and altered rainfall patterns.⁷

The actions taken (or that have failed to have been taken) by Myanmar's government to prepare for and adapt to climate change will have a direct influence on the nation's security. The Rio Earth Summit in 1992 highlighted the potential dangers of climate change and transformed it into an international policy issue. At this time in Myanmar, the State Law and Order Restoration Council (SLORC) was beginning the fourth year of its totalitarian rule after seizing power in 1988 and was more concerned with economic growth and development following the years of an economic program called the "Burmese Way to Socialism" that had impoverished the country. Seeking international legitimacy, the SLORC recognized the 1992 Summit as a way to join the world community, and it therefore became party to numerous international treaties and

⁷ Union of Myanmar: National Environmental Conservation Committee [Myanmar's NECC], Ministry of Environmental Conservation and Forestry, "Myanmar's National Adaptation Programme of Action (NAPA) to Climate Change," 2012, <http://unfccc.int/resource/docs/napa/mmr01.pdf>, 34.

environmental policies. Despite its action on the world stage, it can be argued that signing on to the Rio Summit, the Kyoto Protocol and other similar treaties was done for purely political benefit with little actual legal enforcement.⁸ More recently, the government acknowledged its desire to grow in an environmentally sustainable way, but that it lacks the resources to do so.⁹

This thesis will analyze these three factors to elucidate Myanmar's security vulnerability to climate change. This analysis will examine the hypotheses listed above that: (1) Myanmar's natural environment is vulnerable to the effects of climate change, (2) changes to the natural environment will have significant negative impacts on the security of the human population, and (3) Myanmar's governmental policies have thus far been insufficient to counteract the negative impacts to the nation's security.

D. LITERATURE REVIEW

Understanding and awareness of climate change had gained traction throughout the twentieth century, but did not become a recognized problem that demanded policy action until the mid-1980s when scientific advancements led to a greater synthesis of knowledge. New satellite data, computer modeling, ice core recovery, and technological advancements began to bring into focus the nature of the problem, and consensus in the scientific community became much more unified on the belief that indeed, the climate was warming. Furthermore, a positive correlation between concentration of carbon dioxide (CO₂) in the atmosphere and long-term atmospheric warming became apparent. Comparisons to Keeling's curve predictions of the 1960s began to show the accuracy of that prognostic tool, and new warming measurements had trended upwards with it.¹⁰

Since the 1980s, the clear, compelling evidence has been vigorously analyzed, and consensus that rising greenhouse gasses (GHG) were directly contributing to climate change and global warming has not only persisted, but strengthened. The most recent

⁸ Raymond L. Bryant, "The Greening of Burma: Political Rhetoric or Sustainable Development?" *Pacific Affairs* 69, no. 3 (1996), <http://www.jstor.org/stable/2760923>.

⁹ The Burma Environmental Working Group, "Advocating for Sustainable Development in Burma," August 9, 2012, <http://bewg.org/en/news/111-bewg-sd>.

¹⁰ Daniel Yergin, *The Quest*, (New York: Penguin Books, 2012), 446.

report of the Intergovernmental Panel on Climate Change (IPCC) from 2013 stated that “warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.”¹¹ Greenhouse gas emissions share primary responsibility for the warming, and are produced by the burning of fossil fuels—coal, oil, and natural gas—for energy, among other human and non-human activities. These greenhouse gasses create increased temperatures by trapping energy in the earth’s atmosphere. Though this is necessary for life on the planet, excess warming creates a multitude of problems if an unnaturally large concentration of gasses is present. A warmer atmosphere, ocean, and landmass lead to melting of sea and glacial ice, and rising sea levels. This ultimately causes changes in ocean acidification levels, greater disparity between wet and dry seasons and areas, and can lead to more intense storms, droughts, and floods. On the human level, disastrous effects can occur to “water availability, food production, health, and local and regional economies,” according to a 2011 report of the Defense Science Board.¹² Since 1995, human activity has largely been accepted as a substantial cause of climate change, based on the IPCC second report that stated that “there is a discernable human influence on global climate.”¹³ This statement has been reiterated in following reports, and the 2013 version claimed that “it is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century.”¹⁴ With the potential devastation that climate change could bring, and with human activity a decidedly aggravating factor, little doubt remains that major shifts in policy are on the way.¹⁵

As the understanding of climate change facts became accepted by the international community, further research has been conducted on its effects on the global, regional, and country-level scales. The IPCC has been the leading scholarly voice on the

¹¹ IPCC, *Climate Change 2013: The Physical Science Basis*, 4.

¹² Defense Science Board Task Force, *Trends and Implications of Climate Change for National and International Security*, (Washington, DC: Department of Defense, 2011), 49.

¹³ Yergin, *The Quest*, 484.

¹⁴ IPCC, *Climate Change 2013: The Physical Science Basis*, 17.

¹⁵ “Climate Change: Basic Information,” U.S. Environmental Protection Agency, accessed December 16, 2013, <http://www.epa.gov/climatechange/basics/>.

subject, having released reports in 2007 (AR4) and again in 2013–2014 (AR5) that include thousands of pages of data and analysis stemming from the most recent scientific reports. Having been awarded a Nobel Peace Prize in 2007 and consisting of the leading international scientists and scholars, the IPCC is generally accepted as the most reputable authority on climate change and its impacts. Its work is global in its scope with detail on the continental and regional basis; however, because of this broad reach, country-specific information is limited.

On the global scale, the Earth's temperature has, without doubt, increased in recent decades. In the last 60 years, according to the IPCC, "Warming of the climate system is unequivocal...The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, [and] sea level has risen."¹⁶ In Southeast Asia, temperatures have increased as well. "Across the region, temperature has been increasing at a rate of 0.14 degrees C to 0.20 degrees C per decade since the 1960s...coupled with a rising number of hot days and warm nights, and a decline in cooler weather."¹⁷ Consistent with the global and regional temperature trends, Myanmar has observed nationwide warming since the 1950s. The government of Myanmar, through its Department of Meteorology and Hydrology's National Adaptation Program of Action (NAPA) to Climate Change, has measured climatological changes in the country. According to its report, though there are regional variations, notably a decreasing trend in Magway and Bago states, "over the last six decades, the temperature in Myanmar has increased on average by ~0.08 degrees C per decade."¹⁸ This trend is expected to continue in Myanmar, consistent with predictions globally and regionally. Indeed, it is predicted that the average temperature in the country will continue to rise, reaching at least 0.4 degrees C by 2020 to a maximum of 3.5 degrees C by the end of the century, with the greatest increases in the Yangon and Rakhine regions.¹⁹

¹⁶ IPCC, *Climate Change 2013: The Physical Science Basis*, 4.

¹⁷ Ibid., 1273.

¹⁸ Myanmar's NECC, "Myanmar's NAPA," 26.

¹⁹ Ibid., 29–30.

Changes in rainfall patterns are expected globally and regionally in the coming decades, and data has shown this to be the case in Myanmar as well. In the most recent six decades, the country has seen an average increase of 29 mm per ten year period.²⁰ This increase has not been consistent throughout the nation; however, the Upper Sagaing Region in the Northern Hilly Area shows an increase of ~215 mm per decade and the Bago Region in the Central Dry Zone with an 81 mm per decade decrease.²¹ This trend has been consistent with the IPCC conclusion that “changes in the global water cycle...will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, although there may be regional exceptions.”²²

Further affecting the security of Myanmar is the increased prevalence of climatological hazards and extreme weather events. Cyclone activity in the Bay of Bengal is a constant threat to the nation, highlighted by the devastation of Cyclone Nargis in 2008. Though there are differences of opinion between the IPCC and the Burmese government on the expected frequency of cyclones in the future, it is agreed that the intensity of the storms are to increase. According to the IPCC report’s Asia chapter, “tropical cyclone frequency is likely to decrease or remain unchanged over the 21st century, while intensity (i.e., maximum wind speed and rainfall rates) is likely to increase.”²³ Myanmar’s NAPA claims that cyclone activity has increased in both frequency and intensity in recent years, with cyclones making landfall every three years before 2000, and every year since; it is then claimed that “an increase in the occurrence and intensity of extreme weather events, including cyclones,” is projected.²⁴ Though the numbers are robust, the small sample size could result in an anomaly.

²⁰ Myanmar’s NECC, “Myanmar’s NAPA,” 26.

²¹ Ibid.

²² IPCC, *Climate Change 2013: The Physical Science Basis*, 20.

²³ Yasuaki Hijioka, Erda Lin, and Joy Jacqueline Pereira, “Asia,” in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects*, ed. Rosa Perez and Kazuhiko Takeuchi (Cambridge and New York: Cambridge University Press, 2013), accessed November 6, 2014, http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap24_FGDall.pdf, 32.

²⁴ Myanmar’s NECC, “Myanmar’s NAPA,” 27–28.

The effects of climate change on the natural environment in Myanmar present security concerns for the nation's people. Increased temperatures, variable precipitation extremes, rising sea levels, droughts, floods, and powerful storms will have severe impacts on all aspects of life. Deforestation, loss of biodiversity, energy shortages, and public health issues will all become more prevalent, but the most significant impacts could be on people's livelihoods through changes to the agricultural sector and ethnic-religious violence due to human migration.

Myanmar is a least developed country that relies heavily on the agricultural sector for income, survival, and economic growth. The CIA World Factbook states that the nation relies on agriculture for 38 percent of its GDP, a figure that does not include agricultural processing, which is included in the industrial sector.²⁵ Of the over 55 million people in Myanmar, 70 percent of the labor force is employed in agriculture.²⁶ In *Global Warming and Agriculture: Impact Estimates by Country*, William Cline further discusses the importance of agriculture in Myanmar. With numbers from the 2001–04 timeframe, Cline shows that Myanmar ranked as the 17th highest worldwide producer of four major crops, of which rice was by far the most abundant with 22.6 million metric tons produced.²⁷ With an agricultural sector that weighs so heavily on the livelihood of Myanmar's people, climatic changes will have a disproportionately negative impact in the country. Indeed, Cline's modeling projections show a loss of agricultural production of more than 25 percent in all scenarios.²⁸

The extensive coastal region of Myanmar, and the millions living there, are highly sensitive to the effects of climate change. In the government's NAPA document, it is conceded that the nation's high vulnerability to climate change is exacerbated by the fact that "human populations and economic activities are concentrated in the coastal zone as well as in low-lying lands and are therefore exposed to long-term climatic impacts such

²⁵ Central Intelligence Agency [CIA], "The World Factbook," accessed May 15, 2014, <https://www.cia.gov/library/publications/the-world-factbook/geos/bm.html>.

²⁶ Ibid.

²⁷ William R. Cline, *Global Warming and Agriculture: Impact Estimates by Country* (Washington, DC: Center for Global Development, 2007), 90.

²⁸ Ibid., 74–75.

as sea-level rise as well as an increase in cyclones and storm surge/flooding,” due to its meteorologically perilous geographical position.²⁹ According to the Center for International Earth Science Information Network of Columbia University, data shows that over five percent of Myanmar’s land area lies below five meters in elevation, an area that is home to an estimated 11 percent of the population—a number that is predicted to climb to nearly 14 percent by the end of the century.³⁰ As rising sea levels inundate the low-lying and coastal areas and storm surges negatively impact farmland and fisheries, millions may be forced from their homes, looking to resettle in other areas. With a large Muslim population in Rakhine State on the west coast among the most vulnerable, their migration is likely to cause an increase in ethnic and religious violence as they look to resettle in ethnic-Burmese lands to the east. Furthermore, adjoining Rakhine State to the west is Bangladesh, a nation that appears to be at least as vulnerable to the negative effects of climate change as Myanmar. As tensions already exist between the two nations, further illegal border crossings with forced migration can only lead to further regional tensions.

Security in the face of a threat can typically be mitigated by the actions of those in position of influence; the threat of climate change is no exception. For decades, the international community has made significant attempts at cooperation in the name of environmental issues, including climate change. The United Nations (UN) has been perhaps the most significant player in the field, forming institutions and initiating such treaties as the United Nations Framework Convention on Climate Change, or UNFCCC, under which Myanmar’s NAPA falls, as well as the Kyoto Protocol. Furthermore, regional agreements are in place to mitigate environmental issues and adapt to climate change. Among these are agreements in the Association of Southeast Asian Nations (ASEAN), namely the Roadmap for an ASEAN Community 2009–2015 which has the goal of attaining a Green ASEAN, and an open dialogue with neighboring countries on

²⁹ Myanmar’s NECC, “Myanmar’s NAPA,” 30.

³⁰ Center for International Earth Science Information Network [CIESIN], *Low Elevation Coastal Zone (LECZ) Urban-Rural Population and Land Area Estimates*, Version 2 (Palisades, NY: National Aeronautics and Space Administration [NASA] Socioeconomic Data and Applications Center, 2013), accessed May 15, 2014, <http://sedac.ciesin.columbia.edu/data/set/lec2-urban-rural-population-land-area-estimates-v2>.

environmental and development issues within the Asian Development Bank's Greater Mekong Subregion (GMS). In conjunction with its global and regional partners, Myanmar produces a National Environmental Policy and a National Environmental Performance Assessment Report for the Asian Development Bank (ADB) and the United Nations Environment Program (UNEP).

The government of Myanmar self-reports actions made to mitigate and adapt to environmental degradation and climate change. UN-based programs have inspired Myanmar's implementation of these actions, and the nation is responsible for reporting the progress it makes in doing so. Agenda 21—Myanmar is one such program, as is its National Environmental Performance Assessment report. Most recently, however, as previously discussed, is Myanmar's NAPA. The NAPA is Myanmar's report to the UN on the status of its adaptation implementation programs. In return for its report, the nation receives UN funding under the Least Developed Countries Fund (LDCF), part of the UNEP. As part of its NAPA (2012), Myanmar has identified eight areas of vulnerability to climate change and prioritized adaptation projects within each area for which LDCF funds will be spent. These eight areas in priority order include: "i) Agriculture; ii) Early Warning Systems; iii) Forest; iv) Public Health; v) Water Resources; vi) Coastal Zone; vii) Energy and Industry; and viii) Biodiversity."³¹ Research conducted by the Burmese government resulted in four priority projects in each area of vulnerability, totaling 32 specific projects. Though the governmental agencies that are responsible for carrying out these adaptation goals are identified, details on how and when they are to be completed are not specified, calling into question the viability of these projects.³²

Despite the numerous self-reported adaptation measures, agreements, dialogue partners, and treaties to which Myanmar is party, not all analysis views the government's apparent environmental cooperation as genuine. Tun Myint's work entitled "Environmental Governance in the SPDC's Myanmar" suggests that under the SLORC/SPDC government that held power from 1988 to 2011, economic development and growth was priority number one, to be advanced at all costs, resulting in further

³¹ Myanmar's NECC, "Myanmar's NAPA," 8.

³² Ibid.

deforestation and exploitation of Myanmar's natural resources.³³ The new regime taking power in 1988 did so, in part, as a result of the economic mismanagement of the previous military regime that instituted the "Burmese Way to Socialism." Pre-1988 central planning of the economy and policies that prevented foreign investment resulted in a nation that had fallen behind the rest of the world from a developmental aspect. The SLORC/SPDC regime took aim to change that. Furthermore, the new governmental system, as Myint explains, was unable to enforce environmental protection even when it was desirable to do so. Myint describes the political infighting as leaving "Burma with no constitution, no national legislative body and no independent judicial system...[lacking] fundamental structures of a stable society—such as accountability, good governance and effective and equitable enforcement of the rule of law—that are essential for the sustainable management of environmental...resources."³⁴ Myint is not alone in his evaluation of Myanmar's environmental adaptation failures. In *Pacific Affairs*, Raymond Bryant argues that the environmental policies of the SLORC/SPDC regime were nothing more than a front put on for the benefit of their image in the international community. Similar to Myint's view, Bryant claims that "Burma's rulers have embraced the concept of sustainable development in the belief that such a strategy holds important political benefits, rather than as a result of concern about environmental degradation."³⁵ There is a clear divide between the government of Myanmar's assessment of their environmental policies and the view of independent analysts.

Climate change appears to be having a negative impact on Myanmar's natural resources, and as change accelerates—as the scientific community projects—this impact will worsen. As the people of the nation are so clearly at risk, the impact to the natural environment will profoundly change the way of life for its citizens. Exacerbating the situation is the failure of the Naypyidaw government to not only prepare adequately, but to be in denial of its failures. Without significant—and rapid—changes, the security of

³³ Tun Myint, "Environmental Governnace in the SPDC's Myanmar," in *Myanmar: The State, Community, and the Environment*, eds. Monique Skidmore and Trevor Wilson (Canberra: ANU E Press and Asia Pacific Press, 2007), 189–90.

³⁴ *Ibid.*, 190.

³⁵ Bryant, "The Greening of Burma," 342.

the nation and its people will deteriorate during this critical juncture in its political, economic, and humanitarian development.

E. METHODS AND SOURCES

The purpose of this thesis is not to prove the existence of climate change from a scientific perspective. It is not meant as an evaluation of the scientific basis of the changing climate or the pace of climate change in Myanmar or elsewhere in the world. Furthermore, it is not meant to make a political statement on the causes of climate change. This paper will analyze the effects on Myanmar from a security standpoint. This thesis will be formed with the assumption that climate change is progressing as the scientific community has argued. I do so because, despite the existence of individuals and organizations that are skeptical, the overwhelming majority—97 percent by some accounts—of leading scientific organizations and climate scientists are in agreement on the basic ideas.³⁶

This thesis will analyze Myanmar's vulnerability to climate change, specifically from a security perspective. In doing so, I will examine the most current scientific studies regarding the observed changes to the climate of Myanmar and the region, as well as expert analysis on changes that are predicted based on climate science and computer modeling. This physical science information will then be analyzed through the lens of Myanmar's current social and developmental state to understand its impacts on the human population and civil society. Finally, an analysis of Myanmar's past and present adaptation policies and environmental law will be conducted to understand the depth of the problem and how effectively it has been mitigated.

In addition to the sources previously listed, numerous others will be used. The Burma Environmental Working Group (BEWG) has produced material that examines different aspects of Myanmar's environmental position from different angles—*Advocating for Sustainable Development in Burma* and *Burma's Environment: People, Problems, Policies* are two of the group's notable publications. Governmental policies

³⁶ "Global Climate Change," National Aeronautics and Space Administration (NASA), accessed May 18, 2014, <http://climate.nasa.gov/scientific-consensus>.

have been published as well, and portions of Myanmar's "Environmental Performance Assessment" and "National Environmental Policy" will provide details of past and current policies from the legal and bureaucratic perspective. Finally, outside analysis from news sources and scholarly journals will be used, including but not limited to *The Irrawaddy* and *Pacific Affairs*.

F. THESIS OVERVIEW

This chapter has outlined the subject matter that will be studied, why it is a worthy subject for consideration, and an overview of the information available to use in this analysis. The rest of this thesis will be divided into three chapters before the conclusion. The three primary chapters will examine different aspects of the issues related to climate change and security in Myanmar. Chapter II will examine the physical science of climate change and detail the specifics of how it will affect the natural environment of Myanmar and the region. Chapter III will look at the human population of the country in terms of development, economics, livelihoods, ethnic-religious conflict, and health and infrastructure, and analyze how the changing natural environment will affect Myanmar's people. Chapter IV will then explain the activities of the nation's government regarding actions that have been taken since the 1988 coup to adapt to climate change, prevent further damage, and minimize security issues through environmental law (domestic and international) and adaptation techniques. To conclude the thesis, I will highlight the major issues facing Myanmar in the future and consider how its ongoing transition to a democratic government can influence climate change adaptation as it strives for developmental progress going forward.

THIS PAGE INTENTIONALLY LEFT BLANK

II. EFFECTS OF A CHANGING CLIMATE ON THE NATURAL ENVIRONMENT

A. INTRODUCTION

In recent decades, scientific observation and analysis has shown the Earth's climate system to be changing. The spike in atmospheric greenhouse gas (GHG) levels has paralleled spikes in global surface and atmospheric temperature, sea levels, and surface ocean acidity.³⁷ There is general agreement in the international scientific community that rising GHG levels in the atmosphere have contributed to climatic changes, and that global warming, altered precipitation norms, and rising sea levels are primary effects of these changes.³⁸ In addition to these primary effects, the multitude of secondary effects can be expected to include the increased prevalence of extreme weather events such as storms, droughts, floods, heat waves, increased ocean acidification, and glacial melting, among others. Furthermore, these primary and secondary effects are synergistic, likely leading to an increased rate of change in the future. All of these climatic changes will have consequences on the global natural environment and on human populations. Myanmar, its neighbors, and the South and Southeast Asian regions are all expected to be affected by the changing climate with results that are consistent in direction with global expectations, despite varying degrees.

This chapter will begin with a brief examination of the recent study of climate change throughout the world. This review will focus on expected changes in temperature, precipitation, and sea level, as well as the effect of these changes on the natural environment, including cyclone activity and ocean acidity. This review of global climate change trends will provide context for the examination of the effects of climate change specifically on Myanmar and the nearby region. The purpose of this chapter is to identify and describe the actual and expected effects of climate change and on Myanmar's natural environment in order to set the stage for Chapter III, which will analyze how changes in

³⁷ IPCC, *Climate Change 2013: The Physical Science Basis*, 6–12.

³⁸ *Ibid.*, 11–15.

the natural environment are likely to affect the human population and societal stability in Myanmar.

B. THE STUDY OF CLIMATE CHANGE

Since its establishment in 1988, the Intergovernmental Panel on Climate Change (IPCC) has been the leading voice in climate science. The IPCC was created jointly by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) and endorsed by 195 world governments, including those of Myanmar and the United States.³⁹ Though the IPCC is not a research organization and does not gather first hand climate information, it “reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change,” according to its organizational website.⁴⁰ Based on this information, IPCC scientists have published five comprehensive reports; the first report was published in 1990 and the most recent in 2013. These reports represent mainstream views among climate scientists, but have been criticized by groups that deny the human causes—or even the existence—of climate change, and by others that are critical of the overly conservative nature of the conclusions. Despite these dissenting voices, the IPCC strives to provide an unbiased assessment that is peer-reviewed and as scientifically accurate as possible. Indeed, its professional work in promoting its findings resulted in a Nobel Peace Prize in 2007.⁴¹ Due in part to the IPCC’s efforts to promote scientific understanding of climate change, study of the phenomenon and dissemination of information about it has increased exponentially during the past two decades. As a result, understanding among the scientific community and the general populace alike has grown.

Climate change is an extremely complex field of study developed from a rather simple idea. Climate, as described by Harun Rashid and Bimal Paul, can be defined as

³⁹ “IPCC Members Grouped According to WMO Regions,” UN International Panel on Climate Change, accessed August 27, 2014, <https://www.ipcc.ch/pdf/ipcc-principles/ipcc-countries.pdf>.

⁴⁰ “IPCC Organization,” UN International Panel on Climate Change, accessed August 27, 2014, <http://www.ipcc.ch/organization/organization.shtml>.

⁴¹ “IPCC History,” UN International Panel on Climate Change, accessed August 27, 2014, http://www.ipcc.ch/organization/organization_history.shtml.

“the average weather in a particular region, with *average* constituting a 30 year period;” in its most basic terms, climate change can then be defined as a deviation from this 30 year weather average over the long term.⁴² Too often, the terms *climate change* and *global warming* are used synonymously. In fact, global warming refers only to the temperature aspect of climate change, whereas climate change encompasses not only temperature, but any aspect of weather to include precipitation or wind patterns.⁴³ This confusion is likely prevalent since temperature changes are one of the driving factors of other climatic deviations. For example, rising temperatures affect precipitation rates, as warmer air and water alter evaporation rates and the ability of the air to hold moisture. Stated simply, rising temperatures over a long time horizon affect other aspects of the climate.

Though an in-depth analysis of the causes of climate change is outside the scope of this thesis, a brief explanation is warranted for contextual purposes. Warming global temperatures bring about changes in climate at the regional level. Global temperature increases are the result of both natural and anthropogenic causes, though to what exact degree is in debate. Natural causes of warming come from varying rates of solar radiation and other factors, such as volcanic eruptions. Human causes come from the increased emissions of GHGs into the atmosphere, especially since the industrial revolution in the 1800s. GHGs consist primarily of carbon dioxide, methane, and nitrous oxide, the byproduct of burning fossil fuels, as well as natural water vapor. Increased GHGs in the atmosphere create a greenhouse effect on a global scale. The Earth receives heat energy from the sun through solar radiation, or short-wave, high-frequency energy. The planet then releases energy back into space through long-wave infrared radiation. The presence of GHGs in the atmosphere allows solar radiation in, but prevents thermal radiation from escaping. An abnormal amount of GHGs creates a blanketing, or greenhouse effect, preventing heat energy from escaping. Clearly, a natural amount of GHGs in the atmosphere is necessary, as it prevents major temperature fluctuation between day and

⁴² Harun Rashid and Bimal Paul, *Climate Change in Bangladesh: Confronting Impending Disasters* (Lanham, MD: Lexington Books, 2014), 3–4.

⁴³ “Climate Change: Basic Information.”

night, but increasing levels of GHGs positively alter global temperatures as energy is trapped in the Earth's atmosphere. The result is global warming and climatic changes.⁴⁴

Measurements and predictions of climate change come in various forms. Data from historical observations of temperature and precipitation are deemed reasonably accurate from the mid-nineteenth century, with increasing reliability from the 1950s onward. Current observations come from modern recording data as well as from satellites and other forms of remote sensing. Information from pre-recorded history has been inferred and observed using paleo-climate reconstruction. Model-based predictions for future climatic changes can be inaccurate, though climate models such as the general circulation model (GCM) and providing regional climates for impact studies—regional (PRECIS) model these changes based on a variety of input factors to determine possible outcomes. Throughout this and the following chapters, model-based projections will be based on the IPCC's mid-level modeling outcomes unless stated otherwise.⁴⁵

C. PROJECTED EFFECT

Climate scientists and climate models project Myanmar to be affected by climate change in various ways. Significant effects include changes to temperature, precipitation, and sea level among other aspects of the natural environment. These effects are projected for all areas of the globe, and Myanmar is no exception.

1. Temperature

From the global perspective, warming of the Earth's surface has been observed since at least the mid-1800s and has accelerated in recent decades. According to IPCC reports, “the globally averaged combined land and ocean surface temperature data...show a warming of 0.85 degrees Celsius over the period 1880 to 2012.”⁴⁶ Though averages per decade may vary depending on short term climate variability caused by natural influences or stronger than normal El Nino seasons, the warming trend has continued in a positive

⁴⁴ Rashid and Paul, *Climate Change in Bangladesh*, 5–6.

⁴⁵ Ibid., 20–22; IPCC, *Climate Change 2013: The Physical Science Basis*, 19–20, 29.

⁴⁶ IPCC, *Climate Change 2013: The Physical Science Basis*, 5.

direction, and has increased in recent years. The IPCC claims that, “each of the last three decades has been successively warmer at the Earth’s surface than any preceding decade since 1850,” a phenomenon that indicates that future increases will continue at a higher rate.⁴⁷ As for future warming, the IPCC projects increases in the range of 0.3 to 0.7 degrees Celsius for the near term (by 2035) and between 1.1 and 3.1 degrees Celsius by the end of the century for the mid-range scenarios (RCP 4.5 and RCP 6) when compared to the 1986-2005 average.⁴⁸ Global temperature increases will not be uniform, however, as warming over land areas and the polar regions will be greater than over the ocean.⁴⁹ This regional variation is likely to become more evident by the end of the century as longer term trends can be identified. It is likely that the northern hemisphere will see greater temperature increases compared to the southern hemisphere, with the greatest regional increases in the Arctic. In both hemispheres, however, the greatest warming is likely to occur at the poles. Furthermore, higher latitudes will see greater increases than the tropical regions, with atmospheric temperatures higher over land than over the seas. Despite the lower warming expectations in tropical areas such as Southeast Asia, temperatures are expected to mirror the positive trends expected at higher latitudes, though to a smaller degree. Additionally, changes will occur in seasonal and daily temperatures. According to the IPCC, “there will be more frequent hot and fewer cold temperature extremes over most land areas, on daily and seasonal timescales...[and] that heat waves will occur with a higher frequency and duration.”⁵⁰ Overall temperature increases are projected to affect the world’s oceans as well. The greatest oceanic warming will occur at the surface (to 100 meters) in tropical regions and in the Southern Ocean, with the rise in temperature expected between 0.6 and 2.0 degrees Celsius at the outer ranges of warming scenarios. Ocean warming will occur to a lesser degree in the deeper ocean regions (to 1000 meters), with outer projections at 0.3 to 0.6 degrees Celsius by the

⁴⁷ IPCC, *Climate Change 2013: The Physical Science Basis*, 5.

⁴⁸ Ibid., 20.

⁴⁹ Ibid., 20–22.

⁵⁰ Ibid., 20.

end of the century. Finally, as a byproduct of warming, glacier size, snow cover, and Arctic sea ice will continue to decrease throughout the century in all IPCC scenarios.⁵¹

Temperatures in Myanmar's neighboring countries, like those globally, are projected to increase throughout the next several decades. Following a trend of temperature increases ranging from 0.14 to 0.2 degrees Celsius per decade since the 1960s in Southeast Asia, the IPCC predicts a larger increase by the end of the century, ranging from 0.8 to 3.2 degrees Celsius at the outer edges of the scenario predictions.⁵² In South Asia, and India in particular, the IPCC predicts continued warming with extremely hot days and nights, especially during the summer months.⁵³ Bangladesh, sharing a border with Myanmar's west coast, is modeled to expect an approximate 2.4 degree Celsius increase by mid-century and 3.5 degrees Celsius by 2100 according to different modeling methods.⁵⁴ Thailand, sharing Myanmar's long border on the east, has been predicted to see an average temperature increase of 1.2 to 1.9 degrees Celsius by 2050, with an expected increase beyond that.⁵⁵

Similar to the global projections, temperatures in Myanmar are expected to generally rise at an uneven rate, and this phenomenon has already been observed. Though there has been a general warming since the mid-twentieth century, the geographic makeup of Myanmar has affected this shift with greater warming in some regions and a decreasing temperature trend in other areas. As a large, mountainous country bordering China and India in the north at approximately 30 degrees north latitude and near the Thailand-Malaysia border in the south at approximately eight degrees north latitude, it is unsurprising that climatic variation has varied by region. Mountain ranges encircle Myanmar in a horseshoe shape, running from the west coast, north into Kachin State, and east in the Shan highlands. The Irrawaddy River runs south through the large central

⁵¹ IPCC, *Climate Change 2013: The Physical Science Basis*, 24–25.

⁵² Ibid., 1273.

⁵³ Ibid., 1272.

⁵⁴ Rashid and Paul, *Climate Change in Bangladesh*, 21-24.

⁵⁵ Danny Marks, "Climate Change and Thailand: Impact and Response," *Contemporary Southeast Asia* 33, no. 2 (2011): 231, http://www.academia.edu/2047244/Climate_Change_and_Thailand_Impact_and_Response.

valley, ending at the large delta and the Andaman Sea. A thin strip of land runs south, bordering Thailand on the east and the Andaman on the west.

Observed temperature changes have affected some—though not all—regions to a significant degree thus far. Compared to the WMO’s 1961–1990 average data, nine of the 17 state regions have observed an increase in annual temperature, two have seen decreases, and six have observed no appreciable change (see Figure 2).⁵⁶ Of the nine regions with increasing temperatures, those of Kayin in the southeast and Lower Sagaing in the central dry zone have seen the greatest climb, with a 0.32 and 0.30 degree increase respectively, compared to a 0.65 degree increase globally for the same approximate time period.⁵⁷ Magway and Bago Regions were the two areas with cooling trends, with Magway on the Irrawaddy east of the coastal mountains and Bago in the southeast. Despite the significant temperature changes over time, there appears to be no discernable pattern of change by geographic area (see Figure 3), likely a product of the smaller, country-level scale of the observations compared to the larger, global scale observations used by the IPCC.⁵⁸

⁵⁶ Union of Myanmar Ministry of Conservation and Forestry [Myanmar’s MOECAAF], *Myanmar’s Initial National Communication (INC) Under the United Nations Framework Convention on Climate Change* (Nay Pyi Taw: Ministry of Conservation and Forestry, 2012), 131.

⁵⁷ International Panel on Climate Change [IPCC], *Climate Change 2007: Synthesis Report*, ed. R.K. Pachauri and A. Reisinger (Geneva, Switzerland: IPCC, 2007), 31.

⁵⁸ Myanmar’s MOECAAF, *Myanmar’s INC*, 129.

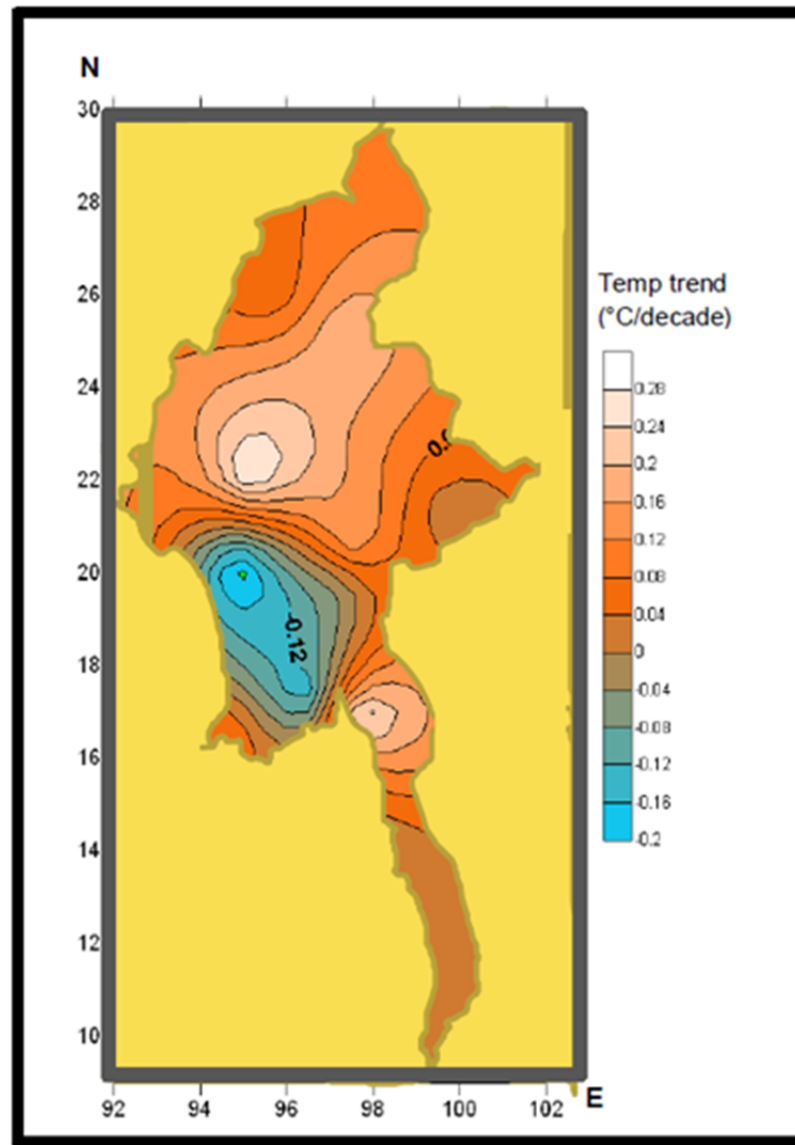


Figure 2. Temperature Trends in Myanmar Compared to the 1961–1990 Average⁵⁹

⁵⁹ Myanmar's MOECF, *Myanmar's Initial National Communication (INC)* [Myanmar's INC], 131.

Sub-State/ Region	Station	WMO Mean Annual Temp (°C) for 1961-1990	Period till 2007		Warming (°C) per decade
			Since	Mean Temp (°C)	
Kachin State	Myitkyina	24	1951	24.1	0.2
Upper Sagaing Region	Hkamti	24	1961	24.1	0.04 *
Lower Sagaing	Monywa	27.1	1961	27.3	0.3
Mandalay Region	Mandalay	27.3	1951	27.5	0.2
Magway Region	Magway	27.5	1971	27.2	-0.23 Cool
Chin State	Hakha	15.8	1981	16	0.13
Rakhine State	Sittway	25.8	1951	27	0.13
Northern Shan State	Lashio	21.8	1951	21.9	0.14
Southern Shan State	Taunggyi	19.1	1951	19.4	0.16
Eastern Shan State	Kengtung	23.2	1951	23	0.01 *
Bago Region	Bago	26.9	1951	26.9	-0.16 Cool
Ayeyarwady Region	Patheingyi	27	1951	27.2	0.08 *
Yangon Region	Kaba Aye	27.4	1951	27.4	-0.04 *
Kayah State	Loileikaw	22.3	1951	27.4	-0.04 *
Kayah State	Hpa-an	27	1961	27.2	0.32
Mon State	Mawlaikine	27	1951	27.1	0.14
Tanintharyi Region	Dawei	26.6	1951	26.6	-0.01 *

Figure 3. Observed Temperature Changes in Myanmar⁶⁰

Projections of future temperature changes in Myanmar follow this uneven trend with a general warming throughout the country. Official Myanmar government models predict that by mid-century, the average temperature in Myanmar will increase by 0.8 to 1.7 degrees Celsius, with the greatest overall warming in the Yangon and Rakhine regions. By the end of the century, increases are expected in the range of 2.8 to 3.5 degrees Celsius, on the higher end of the 1.1 to 3.1 degrees Celsius projected average increase worldwide, again with the greatest impact in Yangon and Rakhine areas. None of the models predict that recent temperature decreases will continue, as all areas of the country are projected to warm. In addition to warming by region, variations are projected to occur throughout the seasons as well. Broken down by season, temperatures during the winter months—December through February—are projected to increase the most, followed by

⁶⁰ Myanmar's MOECAP, *Myanmar's INC*, 129.

those in the March to May timeframe, and finally, the least amount of increase in summer, June through November. Mirroring the IPCC's global predictions, Myanmar is expected to have an increase in days with extreme high temperatures and prolonged heat waves.⁶¹

2. Precipitation

The general warming that has occurred, especially throughout the last century, has had an effect on precipitation levels worldwide, and these changes are predicted to continue. Similar to temperature changes, precipitation changes have not been uniform on a global scale, and even in particular regions, seasonal precipitation has changed. Meteorological science shows that warmer temperatures increase the ability of air to hold moisture as water vapor. As air with more moisture rises from the oceans and moves over land, the air cools, reducing its ability to hold moisture. This results in heavy precipitation events in certain areas and times, while creating droughts in others.⁶² According to the IPCC, more precipitation over land on a global scale is likely to have occurred since the mid-twentieth century, and there is high confidence that similar changes have taken place in the mid-latitudes of the northern hemisphere over the same time period.⁶³ This trend is predicted to continue throughout the twenty-first century. Changes in precipitation are expected to generally increase in scale on the global level, with high variability between regions and seasons; furthermore, contrasts in seasonal precipitation levels are expected to increase between the wet and dry seasons with heavy precipitation and flooding in the wet seasons and prolonged droughts in the dry seasons.⁶⁴ The level of specificity, however, has proven more difficult to determine. The IPCC expects that for the shorter-term time periods, precipitation changes will be highly variable as the significant impacts of yearly weather events such as El Nino southern

⁶¹ Myanmar's MOECFA, *Myanmar's INC*, 62–65; Myanmar's NECC, "Myanmar's NAPA," 28–29.

⁶² "IPCC Frequently Asked Question 3.2: How is Precipitation Changing?" UN International Panel on Climate Change, accessed September 10, 2014, http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-3-2.html.

⁶³ IPCC, *Climate Change 2013: The Physical Science Basis*, 5.

⁶⁴ *Ibid.*, 20.

oscillation (ENSO), and the variable presence of atmospheric pollutants impact precipitation averages.⁶⁵

Precipitation in Myanmar is highly variable by region and season, and changes in precipitation cycles have been observed in recent decades throughout the country. At the national level, Myanmar's observed annual precipitation increased during the second half of the twentieth century, though within 10 percent of normal levels, roughly consistent with global change averages.⁶⁶ To fully understand the impact of precipitation changes, however, data must be considered at the regional and seasonal level. From a regional perspective, 10 of the 17 region-states have observed significant precipitation increases since the mid-twentieth century, while four have observed decadal decreases and three have seen no appreciable change.⁶⁷ There are significant differences in interstate rainfall means as well, and changes in precipitation rates coincide with these differences. Lower Sagaing Region, for example, has the lowest annual rainfall average in Myanmar at 768 mm, based on the WMO's latest 30 year average (1961–1990). As a state in the central dry region, this is expected. Lower Sagaing has also observed a significant decrease in the decadal mean, showing a decrease of 17.4 mm of precipitation through 2007. At the other end of the spectrum are Tanintharyi, Mon, and Rakhine States. Tanintharyi averages over 5400 mm of annual precipitation, and though it is one of the three states that has observed no appreciable change, Mon, with over 4800 mm annually and Rakhine, with over 4700 mm (second and third wettest regions), have seen decadal increases of 71 mm and 52 mm, respectively; two of the highest increases. Based on these observations, it appears that the wet regions are getting wetter whereas the dry regions are getting drier. The disparity between wet and dry regions, and the observed changes between the two, highlights the uneven effect of climate change driven precipitation changes.⁶⁸

⁶⁵ IPCC, *Climate Change 2013: The Physical Science Basis*, 20–23.

⁶⁶ Myanmar's MOECFA, *Myanmar's INC*, 128; IPCC, *Climate Change 2013: The Physical Science Basis*, 22.

⁶⁷ Myanmar's MOECFA, *Myanmar's INC*, 133.

⁶⁸ *Ibid.*, 132–33.

Seasonal variation in precipitation levels throughout Myanmar are largely driven by the monsoon climate. Mid-May to mid-October encompasses the monsoon season in the country where rainfall peaks. Overall, Myanmar has seen a shortening in duration of the typical monsoon season, with a later onset and earlier end.⁶⁹ Data analysis shows that a shorter wet season combined with higher overall rainfall levels has led to more extreme rainfall events in the wet season and a prolonged dry season, leading to greater occurrences of alternating seasonal flooding and drought. According to official reports from government, “rainfall patterns in Myanmar have become unpredictable with regular reports of record-breaking rainfall: Over the period 1960–2009, shorter rainfall seasons in combination with erratic and intense rainfall resulted in numerous flooding events.”⁷⁰ Extreme rainfall events have resulted not only in flooding, but in landslides, and unpredictable precipitation levels in growing seasons. Alternately, the extended dry season has resulted in prolonged droughts, creating problems in the health and agriculture sectors.

Future precipitation levels will be altered by climate change and rising global and regional temperatures. However, these levels and their predictability will vary, especially over the relatively short term. Internal variation, ENSO cycles, and atmospheric pollutants are likely to change precipitation levels on a yearly basis, but over the long term—through the end of the century—predictions can be made with greater confidence in reliability.⁷¹ Based on regional modeling, Myanmar’s government expects precipitation changes to be highly variable across the country in the short term, with overall long term increases in total amounts of rainfall. Regionally, it is expected that the highest increases in annual rainfall will occur in the Rakhine region along the west coast border of the Bay of Bengal, and the smallest increases in the eastern regions of the country. These expectations are generally consistent with recent observations. Rakhine State has already experienced one of the greatest positive precipitation changes in the last six decades, a trend that is expected to continue; changes have been negligible for the

⁶⁹ Myanmar’s NECC, “Myanmar’s NAPA,” 26.

⁷⁰ Ibid., 27.

⁷¹ IPCC, *Climate Change 2013: The Physical Science Basis*, 20.

same time period in southern and eastern Shan State, on the eastern border of Myanmar, and this region is likely to continue to be among the regions with the lowest levels of precipitation increases in the coming decades.⁷² Despite the lesser effects in some areas, it is still expected that an overall long term increase in precipitation level will occur in all regions of Myanmar. From a seasonal perspective, modeling shows an increase in precipitation level to continue in the shorter monsoon season, while an overall decrease in rainfall levels to occur in the dry seasons. Simply put, more precipitation will fall in a shorter period of time, with longer dry spells in between. Because of this dichotomy, predictions of precipitation levels indicate prolonged droughts in the dry season, with more extreme rainfall events and significant river flooding in the wet seasons.⁷³

3. Sea Level

A rise in global sea levels has been observed in recent decades, and with continued global warming temperatures, the IPCC predicts this trend to continue throughout the century. There are two primary factors affecting sea level rise relating to global warming. First is thermal expansion. It is estimated that approximately 60 percent of the global heat energy increases are stored in the upper ocean and 30 percent in ocean waters at greater depths, resulting in total oceanic absorption of 90 percent of heat energy increases.⁷⁴ As ocean waters absorb heat energy, they naturally expand, contributing to rising ocean levels. The second primary factor is melting ice sheets and glaciers. As the Antarctic and Greenland ice sheets melt, as has been observed through satellite data, and runoff from melting glaciers empties into the world's oceans, there is a resultant sea level rise. Indeed, the IPCC AR5 reports with high confidence, "since the early 1970s, glacier mass loss and ocean thermal expansion from warming together explain about 75 percent of the observed global mean sea level rise."⁷⁵ The latest IPCC report also provides an assessment that it is very likely that mean sea levels rose worldwide by approximately 1.7 mm per year since 1901 (through 2010). Furthermore, the rate of rise has increased in

⁷² Myanmar's NECC, "Myanmar's NAPA," 29.

⁷³ IPCC, *Climate Change 2013: The Physical Science Basis*, 28–31.

⁷⁴ Ibid., 8.

⁷⁵ Ibid., 11.

recent decades, with an average of 2.0 mm per year since 1971 and 3.2 mm per year since 1993. In all climate scenarios projected by the IPCC, sea levels will continue to rise throughout the twenty-first century. It is very likely, as reported, that the accelerated rate will continue as the new normal. The Panel expects not only a continued sea level rise, but that the rate will “very likely exceed that observed during 1971 to 2010 [2.0 mm per year] due to increased ocean warming and increased loss of mass from glaciers and ice sheets.”⁷⁶ It becomes clear, and stands to reason, that as global warming melts large ice formations and induces thermal expansion, temperature increases and sea level rise will continue in parallel for the foreseeable future. Figure 4 shows the IPCC projections for these parallel increases under the four scenarios.

		2046–2065		2081–2100	
	Scenario	Mean	Likely range ^c	Mean	Likely range ^c
Global Mean Surface Temperature Change (°C) ^a	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8
	Scenario	Mean	Likely range ^d	Mean	Likely range ^d
Global Mean Sea Level Rise (m) ^b	RCP2.6	0.24	0.17 to 0.32	0.40	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.30	0.22 to 0.38	0.63	0.45 to 0.82

Figure 4. IPCC Projections for Future Temperature and Sea Level Changes⁷⁷

Rising sea levels are likely to affect Myanmar disproportionately because of its vast connection to the sea and its lower levels of economic development. Though rates of sea level rise may not be uniform, the IPCC expects most regions to be within about 20 percent of the global average.⁷⁸ Chapter III will discuss in greater detail the second order effects of sea level rise on Myanmar.

⁷⁶ IPCC, *Climate Change 2013: The Physical Science Basis*, 25.

⁷⁷ Ibid., 23.

⁷⁸ Ibid., 26.

4. Second Order Effects

Related to rising sea levels as a matter of national security concerns in Myanmar are the presence of cyclones, tsunamis, and other natural disasters. An increase in tropical storm activity is difficult to attribute directly to climate change, and the IPCC and the US Environmental Protection Agency have separately failed to definitively implicate global warming for changes in cyclone activity.⁷⁹ Global warming could be playing a part in an increased intensity of these storms, however, as ocean surface temperatures continue to warm. There is little data to support claims of changing cyclonic frequency, though, and the IPCC is careful to avoid such speculation. By the end of the century, however, the Panel projects that an increase in activity and/or intensity is “more likely than not.”⁸⁰

Cyclone activity is a constant concern in Myanmar, and since the destruction brought by Cyclone Nargis in 2008, this concern has been elevated. Despite the suspect reliability of short-term storm data, the government in Myanmar has published its observations that cyclonic activity is on the rise: “In the past (before 2000), cyclones made landfall...along Myanmar’s coast once every three years. Since the turn of the century, cyclones have made landfall along Myanmar’s coastline every year.”⁸¹ Cyclone hazards are highest in the northern coast regions near Sittwe, decreasing toward the south.⁸² Though it is still somewhat unclear what the future impact of climate change will be to the frequency and intensity of cyclonic activity, the increased sea levels expected in the Bay of Bengal and the Andaman Sea make even status quo cyclone levels and intensities more problematic. High winds, heavy rains, and storm surges along the vast coastline of Myanmar during tropical storms create an environment in which even normal cyclone activity can be increasingly disastrous.

⁷⁹ Hijioka, Lin, and Pereira, “Asia,” 6; United States Environmental Protection Agency, “Climate Change Indicators in the United States: Tropical Cyclone Activity,” accessed September 14, 2014, <http://www.epa.gov/climatechange/science/indicators/weather-climate/cyclones.html>.

⁸⁰ IPCC, *Climate Change 2013: The Physical Science Basis*, 7.

⁸¹ Myanmar’s NECC, “Myanmar’s NAPA,” 27.

⁸² Union of Myanmar: Department of Meteorology and Hydrology, *Hazard Profile of Myanmar* (Nay Pyi Taw: Union of Myanmar, 2009), 10.

Ocean acidification as a result of climate change is another second-order effect. As greenhouse gasses are added to the Earth's atmosphere at ever increasing levels from the burning of fossil fuels and from deforestation, concentrations of carbon dioxide, methane, and nitrous oxide rise. Approximately 30 percent of this added carbon dioxide is absorbed by the planet's oceans, raising their acidity levels.⁸³ In fact, as GHG concentrations have risen to 391 parts per million (ppm) by 2011—near post-industrial revolution highs—ocean pH has decreased by 0.1, equating to higher acidity.⁸⁴ This trend of increasing acidification due to carbon uptake in the ocean is expected to continue under all IPCC scenarios throughout the 21st century. For the mid-level scenarios used by the IPCC, pH levels are expected to further decrease within the range of 0.14 to 0.21 by 2100, disturbing the delicate balance in the ocean's ecosystems.⁸⁵

Finally, increased incidents of forest fire may rise with expected climate change. Myanmar is a heavily forested country, with forests accounting for approximately half of the nation's land area; there are extensive forests of various kinds in every region and state.⁸⁶ Each year, thousands of wild fires destroy large areas of the nation's forest, threatening natural ecosystems as well as towns and villages in rural areas. Though many fires are caused by human negligence, many others are the result of natural occurrences such as lightning strikes. No matter the cause, climate change is likely to exacerbate the fire hazard. Longer drought periods lead to drier biological substances, creating conditions in which forest fires can spread at faster rates. Warmer temperatures increase the rate of evaporation, further intensifying these conditions. With Myanmar's reliance on its woodlands for social and economic purposes, protection for its abundant wildlife, as well as the forests' significant role in climate change mitigation, increased rates and intensities of forest fires brought on by climate change may be detrimental to the security and development of the nation.⁸⁷

⁸³ IPCC, *Climate Change 2013: The Physical Science Basis*, 11.

⁸⁴ *Ibid.*, 11–12.

⁸⁵ *Ibid.*, 26–27.

⁸⁶ Myanmar's Department of Meteorology and Hydrology, *Hazard Profile*, 56.

⁸⁷ *Ibid.*, 56–60.

D. CONCLUSION

Climate changes have been observed in the last several decades on the global, regional, and even country levels. Warming temperatures have accompanied an increase in atmospheric greenhouse gasses. Temperature increases have led to a change in precipitation patterns and a rise in global sea levels. These changes are visible on smaller, regional and country-level scales. With heightened awareness of climate change in the international community, organizations such as the IPCC have studied and analyzed all available data and worked with the scientific community to determine what changes can be expected in the future. Their general agreement has been that these changes will continue in the future, causing unavoidable alterations in the way lives are affected. In the next chapter, I will analyze what these climatic changes, and those projected for the future, will mean to the national security and the people of Myanmar.

THIS PAGE INTENTIONALLY LEFT BLANK

III. CLIMATE CHANGE EFFECTS ON THE PEOPLE OF MYANMAR

A. INTRODUCTION

Myanmar is a nation undergoing considerable change. Emerging from decades of military dictatorship, the new 2011 quasi-civilian government is faced with challenges ranging from ethnic violence to economic development and from the need to earn political legitimacy at home to repairing its damaged reputation abroad. None of this has been easy for the country's new leaders, and as they deal with these issues, new problems constantly arise. One such issue is the impact of the changing climate. How does climate change affect the people of Myanmar? There are multiple answers, all depending on which version of the IPCC climate scenarios prove to be most accurate. In each scenario, however, the answers trend in the same direction, though their severity depends only on degree. There are numerous challenges Myanmar will face, but in this chapter I will focus on four major ones. The severity of the problems will depend on many factors, some known and others unknown. How will the world community respond to climate change, and will states, individually or collectively, adapt mitigation measures that result in less severe climate scenarios in the future? Or, will the synergistic effects of global warming result in new, more extreme scenarios that few have imagined? The answer is probably somewhere in between. The degree to which Myanmar is affected depends on the answers to these questions. With more clarity, however, we can anticipate the issues that will arise, even if the degree to which they impact the nation is impossible to know.

In the following sections of this chapter, I will discuss four of the most prominent issues Myanmar will face in dealing with future climate change, including the direct impact for the nation's citizens. First is the impact of climate change on the agriculture of the country, still the most important factor in the lives of Myanmar's people. Following that will be a sobering assessment of the various effects of warming on public health and well-being. Third, I will discuss water resources in the country, an invaluable resource that will be threatened in myriad ways. The final section of this chapter will discuss the

issues people will face in the coastal zone, including loss of agricultural land and essential infrastructure.

B. AGRICULTURE

The importance of agriculture, and rice crops more specifically, in Myanmar cannot be overstated. It is the primary source of employment and the largest single sector of the economy. The very lives of Myanmar's people depend on a flourishing agricultural sector. Currently, agriculture in Myanmar is producing at a sustainable rate countrywide, though there are variations in performance in different areas of the country. Despite the climatic variation between the coastal areas, the dry central zone, and the hilly areas, the constant is a dominant agricultural presence. In the current environment, Myanmar is a net exporter of agricultural products, though future climatic change will stress this positive balance. If, as expected, temperatures rise, precipitation rates change, and abundant fresh water becomes scarce, the agriculture sector of Myanmar's economy will receive a major blow. Agricultural losses would have negative consequences on the nation's economy as well as result in human suffering through increased rates of malnutrition, health problems, and mortality.

The IPCC and the global scientific community project that future climate change will have an overall negative impact on global agriculture production, including in parts of Asia. Indeed, according to the IPCC Fifth Report, "it is projected that climate change will affect food security by the middle of the 21st century, with the largest numbers of food-insecure people located in South Asia."⁸⁸ Like climate change itself, however, the changes in agricultural production and food stability are not projected to be equal across various sub-regions. The reasons for this disparity directly relate to projections for a changing climate. Agriculture production is heavily dependent upon the climate and seasonal weather, and changes in short and long-term trends in temperature and precipitation will affect the ability of a nation's people to produce crops. Furthermore, crop production will be affected by atmospheric carbon, freshwater availability, storm damage, and salt water intrusion from rising sea levels as well.

⁸⁸ Hijioka, Lin, and Pereira, "Asia," 15.

Temperature is the first variable. Evidence has shown that rising temperatures typically boost crop production, specifically rice, Myanmar's most important crop. There is a limit to the positive effects, however, as an upper limit of temperature increase peaks production, and after which further temperature increases stifle growth. It is likely based on this expectation that higher latitude areas of the Earth will benefit most from an agricultural standpoint, while the lower latitudes—already near peak crop production temperatures—will be the most negatively impacted. It is expected that in the near future, global crop production will benefit on the whole from warming, but by the later decades of this century, the trend is projected to reverse, leading to greater food insecurity and negative net global agricultural production.⁸⁹

The next variables to impact agriculture are precipitation and fresh water availability. Most crops depend on a steady, predictable amount of precipitation throughout the growing season, and in the absence of this, fresh water from irrigation is relied upon to sustain plants as they develop to maturity. Climate change in the coming decades, as discussed in the previous chapter, is expected to alter patterns of rainfall in many areas of the Earth, including Myanmar. Some areas are projected to see an increase in rainfall, while others will experience a significant decrease. Even in regions where overall rainfall amounts are likely to remain stable on average, the seasonal variations are likely to be great. Shorter, more intense rainy seasons, especially in areas of south and Southeast Asia, are projected to occur while prolonged droughts are likely in the dry seasons. This variation in precipitation and available fresh water will have significant effects on agriculture, and will demand considerable adaptation methods to maintain crop output on both the global and regional scale.

Storm damage and salt water inundation are also potential threats to sustainable agricultural production. Many crop-producing areas of the world, specifically in Asia, are located in low-lying delta areas near expansive coasts that are susceptible to seasonal cyclones. Countries from Japan and Vietnam to Myanmar and Bangladesh rely heavily on rice production, as well as many other crops, for social and economic reasons. These

⁸⁹ Cline, *Global Warming and Agriculture*, 1–2.

countries grow crops in abundance in the low lying deltas of the Mekong, Irrawaddy, and numerous other rivers, areas that are well suited to production, but also susceptible to heavy storm damage. Cyclones bring not only heavy winds and drenching rains that can cause crop damage, but just as significantly, storm surge that can inundate growing areas with salt water from the sea. Rising sea levels in normal times can cause intrusion as well, but when combined with a high storm surge from a tropical cyclone, they can be catastrophic.

A final variable to be mentioned is the increasing presence of atmospheric carbon. There is great debate over the effects of carbon in the atmosphere relating to crop production, but with further research, some details have become clear. Carbon dioxide, the greenhouse gas that contributes to global warming, is an important piece of the photosynthetic process plants use for growth. Some researchers have estimated that even though increases in carbon dioxide in the atmosphere contribute to climate change, it also is a positive factor in crop production. Other studies have argued that this phenomenon, known as carbon fertilization, is overestimated. Indeed, William Cline has stated that, “recent research based on experiments with the free air concentration enrichment method suggests that past estimates of the carbon fertilization effect have been substantially overstated,” likely as a result of smaller scale lab testing.⁹⁰ Though carbon fertilization has shown a positive effect on crop growth, the temperature increases and other climatic changes as a result of higher carbon concentrations may prove to have a net negative effect on overall agricultural output, especially at lower latitudes.

Agriculture continues to be the largest share of the economy in Myanmar. Despite a steady decrease as a percentage of GDP between 2000 and 2010, agriculture was still estimated at over 36 percent, down from 57 percent in 2000.⁹¹ The largest gains in GDP as a percentage of the economy were seen in the industrial sector, according to the Asian Development Bank.⁹² There is an estimated 11 million hectares of agricultural land in use

⁹⁰ Cline, *Global Warming and Agriculture*, 24.

⁹¹ *Greater Mekong Subregion Atlas of the Environment*, 2nd ed., Asian Development Bank, December 2012, <http://www.adb.org/sites/default/files/pub/2012/gms-atlas-environment-2nd-edition.pdf>, 264–65.

⁹² “Greater Mekong Subregion Atlas,” 264–65.

in Myanmar, producing over 60 primary crops, with rice as the most abundant at over 31 million metric tons (see Figure 5).⁹³ Rice is the staple food in Myanmar, a country with one of the highest per capita rates of rice consumption globally. Furthermore, in addition to the high rates of rice consumption and rice's large contribution to Myanmar's GDP, agriculture comprises over 13 percent of the nation's export earnings, a high percentage given the low value added nature of the product. Though agriculture's share in GDP has gone down in recent years, this is due more to growth in industrial and services sectors, as well as the expansion of natural resource production, specifically oil and lumber. However, the agricultural sector is still, by far, the most important source of employment in the economy with an estimated 70 percent of the labor force.⁹⁴ With agriculture accounting for 38 percent of GDP, 13 percent of the nation's exports, employment of 70 percent of the labor force, as well as its position providing food and livelihood for tens of millions of people, the importance of agriculture in Myanmar cannot be overstated.⁹⁵

Year	Sown (^{'000} ha)	Harvested (^{'000} ha)	Yield (Mt* / ha)	Production (^{'000} Mt*)
1995-96	6138	6033	3.08	18580
2000-01	6359	6302	3.38	21324
2002-03	6488	6377	3.42	21805
2004-05	6858	6808	3.64	24752
2005-06	7389	7384	3.75	27683
2006-07	8125	8074	3.83	30924
2007-08	8090	8011	3.93	31451

*Metric ton

Figure 5. Myanmar's Rice Activity by Year⁹⁶

Given the overall importance of rice and other agricultural products to Myanmar, a look at the expected impact of climate change on the nation's farming sector is

⁹³ Myanmar's MOECF, *Myanmar's INC*, 68.

⁹⁴ CIA, "World Factbook."

⁹⁵ Myanmar's MOECF, *Myanmar's INC*, 68.

⁹⁶ Ibid.

essential. The multitude of factors affecting the nation, as well as the seasonal and yearly variability, make near term predictions unreliable. El Nino years, yearly cyclonic activity, and seasonal precipitation variation prevent these short-term predictions from being reliable, though longer-term assessments based on climate modeling are more credible predictors of production levels later in the century. William Cline provides likely estimates for many countries and regions, including Myanmar, for the last three decades of this century, 2070–2099, based on two accepted modeling methods: the Mendelsohn-Schlesinger model and the Ricardian model. Each prediction is modeled both with and without the presence of carbon fertilization, and the models with the inherent unknowns of carbon fertilization lead to larger discrepancies in the CF predictions. Without carbon fertilization, the two models predict a negative 66 and negative 67 percent change in agricultural output per hectare respectively when adjusted for inflation.⁹⁷ The models that incorporate carbon fertilization are vastly different, with a negative 55 and negative 23 percent change.⁹⁸ Despite the variability of the two models dealing with carbon fertilization, the results show a clear negative trend, with the difference only a matter of degree, albeit a large one. Because the effects of potential carbon fertilization are not yet clear, more research must be conducted to determine the likely influence. Cline’s research and analysis, as previously mentioned, has led to his conclusion that the projected influence of carbon fertilization has been overstated, and in this case, the results of the climate models show severe consequences for the future of Myanmar’s agricultural output if stringent adaptation methods fail to be adopted.

The loss or severe degradation of agricultural production in Myanmar has the potential to further destabilize the late developing nation. With millions of people losing employment, poverty rates and livelihoods would be negatively affected. Large numbers of people living in severe poverty would increase and subsistence farmers may fail to provide food products at the local level. The economy, despite its recent diversification, would be negatively impacted, and the 13 percent of export expenditures currently enjoyed by the Myanmar economy would be lost to feed the nation’s own people. It is

⁹⁷ Cline, *Global Warming and Agriculture*, 126, 131.

⁹⁸ Ibid.

likely that Myanmar would then be left to rely on foreign assistance to make up for the losses. In any case, it is clear that the government and people of Myanmar must begin to implement adaptation methods to adjust to the impact of climate change on agriculture. Greater planning for irrigation methods for dryer areas and greater use of drought and flood-resistant seed varieties are two steps to begin the process of adaptation.

C. PUBLIC HEALTH

Climate change and global warming create conditions that will negatively affect public health in Myanmar and worldwide. Many of these effects are projected to come as a direct link, such as heat-related morbidity, while others will occur indirectly. While some health effects are projected to decrease, such as cold weather injury, illness, and death, they are severely outweighed by the increase in other effects. Most models predict Myanmar will be disproportionately affected by climate change in regards to public health. As one of the world's poorest countries, it has very limited capacity to adapt to climate change; moreover, its location in the lower latitudes, combined with its vast coastline, creates even greater opportunities for health calamities. This section will analyze the major effects of climate change on public health in Myanmar, including heat-related health issues, physiological illness and disease, and the spread of vector and water borne disease, among other indirect effects.

Heat related illness and death are likely to increase with rising temperatures in Myanmar. As discussed in the previous chapter, overall temperatures in the country are expected to rise in varying degrees based on modeling of different climate scenarios. Furthermore, heat waves of greater duration and intensity are expected to become more prevalent. In a lower latitude country such as Myanmar where temperatures are often on the higher end of the spectrum in normal conditions, further increases are likely to have increased consequences. In May 2010, a heat wave descended on central Myanmar, claiming the lives of hundreds. According to the Democratic Voice of Burma, "a near unprecedented heat wave in Burma that has pushed temperatures as high as 47 degrees Celsius...continues to claim lives," and that "health authorities in...Mandalay...[said]

that more than 230 people had so far died of heat related illnesses.”⁹⁹ Further temperature increases and greater incidence of heat waves are likely to exacerbate the issue. Heat wave morbidity has the potential to become a regularly occurring public health issue.

Higher temperatures are also likely to increase the rate of physiological disease, specifically cardiovascular and respiratory disease. These chronic illnesses relate directly to temperature because of the correlation of temperature with atmospheric allergens and pollution. As temperature increases, earlier and longer lasting production of pollen and mold spores, as well as other airborne allergens, will become normal. Additionally, higher temperatures increase the presence of lower level atmospheric ozone and air particles, which increases susceptibility to respiratory and cardiovascular disease. According to the U.S. Centers for Disease Control and Prevention (CDC), these fine particles correlate to “negative cardiovascular outcomes such as heart attacks, formation of deep vein blood clots, and increased mortality,” as well as “decreased lung function, aggravation of asthma, rhinitis, [and] exacerbations of chronic obstructive pulmonary disease;” furthermore, as temperatures rise, these results are intensified.¹⁰⁰

Negative impacts to public health include vector, food, and water borne illnesses. These illnesses are a severe issue for the people of Myanmar as it is calculated to have a “very high” risk for major infectious diseases, and with warming temperatures, the problem will only get worse.¹⁰¹ Myanmar’s health sector is ill equipped to deal with epidemics. According to the CIA World Factbook, the nation expends only two percent of GDP on health, ranking it as the 189th of 190 surveyed countries.¹⁰² Furthermore, Myanmar ranks near the bottom in life expectancy, at just under 66 years, a ranking of 170 out of 223 countries surveyed.¹⁰³ Malaria is one of the most prevalent vector-borne serious diseases in Myanmar. The government of Myanmar contends that cases of

⁹⁹ Aye Nai, “Heatwave Kills 230 in Mandalay,” *Democratic Voice of Burma*, May 20, 2010, <http://www.dvb.no/news/heatwave-kills-230-in-mandalay/9091>.

¹⁰⁰ “Asthma, Respiratory Allergies, and Airway Diseases,” Centers for Disease Control and Prevention, accessed October 9, 2014, http://www.cdc.gov/climateandhealth/effects/airway_diseases.htm.

¹⁰¹ US CIA, “World Factbook.”

¹⁰² Ibid.

¹⁰³ Ibid.

malaria have decreased significantly since 1988, a reduction from nearly 25 cases per 1000 people to 10 in 2008, though the number remains high and is disputed by the World Health Organization.¹⁰⁴ Other communicable diseases of concern in Myanmar are bacterial diarrhea, hepatitis A, typhoid fever, dengue fever, and Japanese encephalitis, a deadly mosquito-borne virus. As concerning as the rates of infection and illness are to the people of Myanmar now, they are expected to get worse with climate change. The government of Myanmar recognizes this distinct possibility, as it mentions in the NAPA that “increasing temperatures and erratic precipitation patterns will create favorable conditions for the spread of infectious disease...Furthermore, pathogen distribution will increase in range as vectors harboring parasites infest highland areas which at present are too cold for vector insects.”¹⁰⁵

There are many other significant factors affecting public health in addition to those discussed above. Water resources will be affected, which is an extensive topic that will be discussed in the next section of this chapter. Agriculture, as previously mentioned, will have negative health effects in addition to those socioeconomic in nature. Food availability is likely to decrease, and therefore the price of the food that is available will increase, creating hardships for individuals and families, especially among the extremely poor, elderly, and young. This creates conditions in which malnourishment is prone to rise, especially in those more vulnerable groups. Finally, coastal areas are likely to be additionally affected by health problems in the face of natural disasters. With rising sea levels, coastal areas with low-lying delta land will see greater destruction with severe weather events, including cyclones. These disasters are capable of damaging public health and infrastructure services; storm surges can damage sewage and fresh water infrastructure, contaminating food, drinking water, and spreading disease throughout cities and villages. Additionally, unprotected public health facilities—including

¹⁰⁴ Union of Myanmar Ministry of Health, *Myanmar Health Statistics 2010*, accessed October 9, 2014, <http://www.moh.gov.mm/file/Myanmar%20Health%20Statistics%202010.pdf>, 50; World Health Organization, *World Malaria Report 2010*, accessed October 9, 2014, http://whqlibdoc.who.int/publications/2010/9789241564106_eng.pdf?ua=1, 50.

¹⁰⁵ Myanmar’s NECC, “Myanmar’s NAPA,” 34.

hospitals—can be damaged and rendered unusable, preventing those in need from receiving health care at a time where demand for such services will peak.

D. WATER

The availability of fresh water resources, already a concern in Myanmar, is an issue that will be exacerbated by climate change. In some areas of the country, fresh water availability is in short supply due to periods of drought in an already dry climate, while in other areas, fresh water is threatened by flooding and storm surge. A decrease in usable fresh water becomes a threat to the people of Myanmar as this resource is in demand on a variety of levels. First and foremost, fresh water is necessary for domestic uses such as having clean drinking water, availability for cooking, and for sanitation purposes. Furthermore, it is critical for agricultural use and for industry, and therefore the livelihoods of the people on a socioeconomic level. There are abundant sources of fresh water for use in Myanmar with the presence of numerous river basins and ground water sources, but the demand for this resource will continue to grow as the population rises, and as the nation's economy expands and grows from its lower levels of development to that of a modern nation. Coinciding with this economic and population growth, climate change will threaten the availability of fresh water, creating availability deficiencies and greater competition for the resource. In the paragraphs below, I will analyze the threat of decreased fresh water availability by examining Myanmar from both the Central Dry Zone and from the river delta areas near the coast, highlighting how decreased fresh water sources will impact each region from two very different perspectives.

The threat to fresh water is seen with the most clarity in the Central Dry Zone of Myanmar, an area of the country that by nature has ongoing availability issues. The Central Dry Zone accounts for approximately ten percent of the land area in Myanmar, primarily covering parts of the Magway, Mandalay, and Sagaing Divisions in the central part of the country in which 54 townships are located.¹⁰⁶ This Zone is surrounded by mountains on the west, north, and east, opening south toward Bago and Yangon. Like other parts of Myanmar, the Central Dry Zone's precipitation varies with the monsoon

¹⁰⁶ Myanmar's Department of Meteorology and Hydrology, *Hazard Profile*, 14–15.

seasons, with May through October representing the wet season. The mountain ranges that nearly surround this area, however, effectively block much of the precipitation, creating a rain shadow area that, even in the wet season, allows this area to remain relatively dry. Where the national precipitation annual average hovers around 2300 to 2400 mm per year, the Central Dry Zone receives less than 750 mm annually.¹⁰⁷ Fresh water resources available for domestic, industrial, and agricultural use are typically rain fed in the Central Dry Zone, and the people there rely on reservoirs, rivers, and ground water to maintain the supply. Droughts, such as those in 2008 and 2009, have had adverse yearly effects on the supply of water available, and further droughts that are extensive and prolonged—such as those projected by climate change—have the potential to diminish water availability on a permanent basis. Furthermore droughts brought on by a changing climate, especially when combined with a shorter monsoon season and an El Nino year, are likely to exacerbate the negative effects. According to the Myanmar Times, the 2009 drought provided an example, as the late onset monsoon in an El Nino year put Mandalay—Myanmar’s second largest city by population—on pace for a well below average precipitation year through August.¹⁰⁸ The shift to perennially lower rainfalls is likely to have devastating effects in the Dry Zone. Though some river water pumping projects have begun to take place, these rivers are also dependent on precipitation, and are therefore influenced by drought. Similarly, ground water availability is subject to replenishment through precipitation. With the expected increase in demand for water resources, combined with the lower replenishment rates in water reservoirs, rivers, and groundwater sources due to a changing climate, fresh water shortages are likely to become more of a regular occurrence with devastating effects for the people of Myanmar’s Central Dry Zone.¹⁰⁹

Reduced fresh water availability and contamination is expected in the low lying river delta areas of Myanmar’s coastal regions as well. Flooding and damage to

¹⁰⁷ Myanmar’s Department of Meteorology and Hydrology, *Hazard Profile*, 17.

¹⁰⁸ Kyay Mohn Win, “Mandalay Rainfall Down 12.6 Percent in 2009,” *Myanmar Times*, August 24, 2009, <http://www.mmmtimes.com/index.php/national-news/6160-mandalay-rainfall-down-12-6-percent-in-2009.html>.

¹⁰⁹ Myanmar’s MOECAAF, *Myanmar’s INC*, 68–70.

freshwater infrastructure, sewage system damage, and salt water intrusion are likely to be some of the largest obstacles to coastal areas. As related in Myanmar's INC, global warming will disproportionately hit coastal countries, especially in Southeast Asia: the "Ayeyarwady delta would be endangered by rising sea level and storm surge. Rising sea level may lead to increased saline intrusion into coastal and island aquifers."¹¹⁰ Higher sea levels combined with cyclone storm surges can overwhelm low lying coastal areas and river deltas creating these problems. In addition to storm surge floods, Myanmar is susceptible to riverine floods in the delta areas, flash floods in the more mountainous areas of the upper river systems, and localized floods in urban areas; not all of these flooding events are necessarily undesirable, but their rising frequency and intensity could cause serious issues.¹¹¹ Riverine floods as a natural occurrence are welcome at their current rates, as they spread nutrients from the upland river areas to farmland in the deltas. Flash floods typically occur in the upper, more mountainous areas, and are responsible for many landslides and damage to human and natural structures. Localized floods in urban areas are typically the result of heavy rainfalls, saturated ground water levels, or damaged infrastructure. Such flooding in highly populated areas can spread disease through backed up sewer systems and contamination of drinking water, and cause further damage to buildings, infrastructure, and farmland. Flooding has gotten worse in recent decades with the changing climate and the changing monsoon duration leading to shorter periods of heavier rainfall.¹¹² In 2008, the same year that Mandalay was suffering a prolonged drought, coastal regions were receiving higher precipitation rates, leading to floods in the coastal river delta areas, including near-record levels in Bago and Shwegyin.¹¹³

Fresh water resources are scarce in some areas of Myanmar, while other areas are susceptible to fresh water contamination and damage due to flooding and salt water intrusion. The Central Dry Zone is particularly at risk of fresh water scarcity with its

¹¹⁰ Myanmar's MOECFA, *Myanmar's INC*, 70.

¹¹¹ Myanmar's Department of Meteorology and Hydrology, *Hazard Profile*, 49.

¹¹² *Ibid.*, 53.

¹¹³ *Ibid.*

increased demand and decreasing supply, an issue that will only get worse as the climate changes. Riverine areas, deltas, and coastal zones are at particular risk of contamination due to floods and storm surges. These problems have already begun in recent decades with changes to the monsoon duration and the presence of El Nino, perhaps a prelude to future norms in a warming world. According to Myanmar's Hazard Profile, "the impacts of climate change and global warming can make the water level reduce in the Central Dry Zone, resulting in water shortages, while the water level in the Delta Region will rise due to the change of sea level."¹¹⁴ With clean fresh water so integral to the lives of Myanmar's people, including the domestic, agricultural, and industrial sectors of the developing economy, reductions in a changing climate could be quite damaging.

E. COASTAL ZONE

Many issues along Myanmar's 2400 kilometer coastline are likely to be aggravated by climate change. This is especially true due to the geographic makeup of the coast, the population density in these areas, its propensity for cyclonic activity, and the rising sea level. As mentioned in the previous section, the low lying delta areas are susceptible to flooding, which poses a threat to the population and infrastructure. The rising sea levels along the coast increase the likelihood of severe and prolonged floods, even total inundation in these areas could make habitation impossible and therefore lead to waves of human migration. A document submitted to the United Nations by the Burmese government substantiates this analysis: "Sea level rise and associated impacts will threaten coastal ecosystems, agricultural land, and infrastructure...Certain low lying coastal zones will be at risk of complete inundation resulting in a loss of agricultural and residential land;" the assessment continues, "the low lying Ayeyarwady Delta is particularly at risk as even a small rise in sea level will lead to a large portion of the Delta being inundated."¹¹⁵

The coastal zone, particularly in the Ayeyarwady and Yangon Divisions, are at the greatest risk of suffering the negative impacts of climate change. The geographic

¹¹⁴ Myanmar's Department of Meteorology and Hydrology, *Hazard Profile*, 54.

¹¹⁵ Myanmar's NECC, "Myanmar's NAPA," 35.

makeup of the area, as an intersection of numerous river deltas, is low lying with many wide river mouths, increasing its susceptibility to flooding and inundation. Just as significant as the region's geography is the population. Yangon, the country's largest city by population with over 5.2 million people, lies on the coast in the division of the same name.¹¹⁶ Yangon and Ayeyarwady divisions are the most populous regions in the country, at approximately 7.3 million and 6.2 million people respectively, and are two of the three regions with the highest population densities, according to the preliminary results of the 2014 census.¹¹⁷ Furthermore, these two divisions are among the areas most at-risk to the negative impacts of climate change, including flood, storm surge, sea level rise, and intense rains.¹¹⁸ Large populations of people living and working in crowded areas that are highly vulnerable to climate change set the conditions for greater catastrophes in the future.

Another view of Myanmar's geography and population gives an equally concerning picture of the impacts of climate change on the country's coastal zones. Viewing the affected population by political division has provided one sense of potential impacts, but another equally significant picture can be seen by looking at the population in relation to elevation. Columbia University's Center for International Earth Science Information Network (CIESIN) published a 2013 data analysis that included past data and predictions on Myanmar's population in relation to sea level. The results of this study revealed that in 2010, 1.4 percent of the population, or over 660,000 people lived at an elevation at or below one meter above sea level; based on their projection, this total number is expected to rise to over 800,000 by the end of the century.¹¹⁹ Even more concerning for Myanmar's people, 2.7 percent, or over 1.3 million people lived at or below three meters above sea level, a number that is expected to rise to nearly 1.6 million

¹¹⁶ Union of Myanmar Department of Population, *Population and Housing Census of Myanmar, 2014: Provisional Results* (Naw Pyi Taw: DOP, 2014), http://www.dop.gov.mm/wp-content/uploads/2012/12/Census_Provisional_Results_2014_ENG1.pdf, 11.

¹¹⁷ Ibid., 6, 11–12.

¹¹⁸ Myanmar's NECC, "Myanmar's NAPA," 32.

¹¹⁹ CIESIN, *Low Elevation Coastal Zone*.

by 2100.¹²⁰ If sea levels rise a mere half meter by the end of the century, a number within the bounds of the majority of scenario projections, up to ten kilometers inland of the current coastline is likely to become uninhabitable.¹²¹

Displacement of hundreds of thousands of Myanmar's citizens from their homes due to sea level rise would be greatly destabilizing for the developing country, and possibly for the region as a whole. Aggravation of existing ethnic conflicts is a major source of concern in such a scenario. Myanmar is comprised of over 150 recognized ethnicities, and conflict among these groups has dominated many of the internal struggles in the rapidly changing political and economic sphere since independence in 1948. The Ayeyarwady and Yangon regions are comprised of mainly majority ethnic Burmans, whereas Rakhine State on the west coast includes thousands of Rohingya Muslims, a separate ethnic group that is under constant persecution.¹²² Loss of habitable living space and agricultural land along the coasts has the potential to drive these two opposing groups together, creating further ethnic violence and instability. The Rohingya as an ethnic group are not counted as citizens of Myanmar by the majority Burman government, and millions have been displaced or have fled to neighboring countries such as Bangladesh, Thailand, or Indonesia.¹²³ Further mixing of these ethnic groups or increased flight to neighboring countries is likely to create further instability at a time when the nation is attempting to emerge from its least developed label.

F. CONCLUSION

Myanmar faces countless challenges in the coming century, and the threats posed by climate change have the potential to be among the greatest. Agricultural land will be threatened by excessive flooding, prolonged drought, and seawater inundation. The spread of disease by water, food, and vector borne viruses are likely to expand to areas

¹²⁰ CIESIN, *Low Elevation Coastal Zone*.

¹²¹ Myanmar's MOECA, *Myanmar's INC*, 66.

¹²² Human Rights Watch, "All You Can Do is Pray: Crimes Against Humanity and Ethnic Cleansing of Rohingya Muslims in Burma's Arakan State," April 2013, http://www.hrw.org/sites/default/files/reports/burma0413webwcover_0.pdf, 4–17.

¹²³ "Flooding Threat Adds to Woes of IDP's in Myanmar's Rakhine State," *IRIN News*, July 7, 2014, <http://www.irinnews.org/report/100313/flooding-threat-adds-to-woes-of-idps-in-myanmar-s-rakhine-state>.

and people who have thus far been isolated by their geographic isolation. Fresh water resources will become scarce, and seasonal variation in precipitation will stress communities in previously unseen ways. Those residing in coastal areas may be the most negatively affected, with the changing climate threatening the very land they inhabit. Regardless of the severity of climate change's effects through the rest of the century, the people and the government of Myanmar can implement adaptation methods to blunt the negative impacts. The next chapter will analyze what has been done thus far to adapt to these impacts, and give an assessment of how well prepared the nation is to deal with a warming future.

IV. CLIMATE CHANGE ADAPTATION IN MYANMAR

A. INTRODUCTION

In May 2008, the tragedy of Cyclone Nargis indicated that the SPDC was a government that had failed to prepare adequately for environmental disasters. The deaths of nearly 140,000 people and the widespread destruction of infrastructure showed how badly the state that had neglected the environment and disaster preparedness. The reality of the situation, however, was much more complex. The leaders of the SLORC/SPDC, after taking power in the 1988 coup, found themselves in a dire situation. The previous military regime, following strict isolationist and socialist policies, had left behind an extremely impoverished and underdeveloped country with little infrastructure, a poor economy, and a weak bureaucracy. Early regime policies focused on building national unity and achieving economic growth, often at the expense of the environment. As the regime matured, however, its awareness of environmental issues, and the need to adapt to climate change, grew. The early SLORC regime initially created weak environmental laws, such as the Forest Law of 1992 that protected economic interests over the environment, and opened the country to foreign companies from Thailand and China, resulting in the destruction of the natural environment. By the time the junta relinquished governmental power, however, they had published Myanmar's National Sustainable Development Strategy and had begun formulating the National Adaptation Program of Action (NAPA). With the 2011 transfer of power to the current Thein Sein government, the SLORC/SPDC left Myanmar better off in this regard than when it took over in 1988. Though few major adaptation projects had been enacted by that time, a significant portion of the framework was in place. Among the most important actions that can be taken in preparation for climate change are enacting strong and effective environmental policies, adopting environmental impact assessment laws, developing a national adaptation strategy, and securing funding to implement these policies. Myanmar is still poorly prepared to face the challenges of climate change; recently, however, the successive governments have taken many of the above actions, suggesting an evolving good-faith commitment to enacting adaptation measures that will enable the country to meet the

challenges of the changing climate. The remainder of this chapter will step through this argument, beginning with a discussion of the parallel rise of the SLORC and global climate change awareness, the evolution of the junta's environmental action from the beginning of the SLORC period in 1988, and finally, an analysis of the current state of adaptation in Myanmar.

B. BACKGROUND

In 1988, as climate change awareness began to rise within the international community, a new military coup seized power in Burma, installing the State Law and Order Restoration Council (SLORC) as the single party head of government. The new regime was inefficient in its newfound role as governmental decision makers, as General Ne Win was the ultimate authority figure from 1962 until the uprising in 1988 led to his ouster. While climate change and environmental issues were capturing the attention of the international community in the late 1980s and early 1990s, the SLORC's attention was focused on national stability. In those early years, the SLORC aimed to quell long-running rebellions by Burma's ethnic minorities, revive the country's economy (which had stagnated under Ne Win's socialist and isolationist policies), and install a system of governance that was starkly different than its predecessor. Environmental issues, despite their growing recognition as a global concern by the developed world, were not treated as an existential threat by the SLORC, and therefore were not given serious attention. The junta formally presided over the government for the next 20 years, until elections in 2010 allowed for quasi-civilian control as former-general Thein Sein of the Union Solidarity and Development Party (USDP) ascended to the presidency in 2011 with the constitutionally mandated 25 percent of military members, backing the USDP, in parliament. By this time, as the SLORC/SPDC's governmental competence had progressed, climate change concerns had earned the regime's attention and more serious action had been taken.¹²⁴

¹²⁴ Tin Maung Maung Than, "Myanmar: Preoccupation with Regime Survival, National Unity, and Stability," in *Asian Security Practice: Material and Ideational Influences*, ed. Muthiah Alagappa (Stanford: University Press, 1998), 391–415; Andrew Selth, "Even Paranoids Have Enemies: Cyclone Nargis and Myanmar's Fears of Invasion," *Contemporary Southeast Asia* 30, no. 3 (2008), 380–88.

Climate change became a global issue in 1988 with the formation of the IPCC at the United Nations; the group published its first report in 1990 and the UN then held the Rio Earth Summit in 1992. Environmental action and protection in Myanmar at the time took a backseat to national stability and economic growth as the junta was just learning to govern. In order to attract foreign investment, international assistance, and gain legitimacy, the government signed international treaties on climate change and adopted domestic policies that gave the appearance of protecting the environment. In the early years of the regime, however, the SLORC did not act on these agreements. Climate change adaptation and environmental protection were neglected in favor of economic growth as the junta sold off the country's vast natural resources and failed to enforce environmental protection policies. As time went by, the SLORC—renamed the State Peace and Development Council (SPDC) in 1997—increased its administrative competence, at least in relative terms. In parallel, global climate change awareness continued to grow with further IPCC reporting and the adoption of the Kyoto Protocol in late 1997. As these developments advanced together, SLORC/SPDC policies showed greater consideration for the environment and for climate change adaptation. By the time the new government took over in 2011, policies and reports had been produced and modest steps had been taken toward laying a foundation for climate change adaptation.

C. POLICY EVOLUTION

Policies on environmental protection and climate change adaptation progressed slowly under the SLORC/SPDC, but have since built momentum in recent years after accelerating toward the end of the regime's time in power. The early SLORC years resulted in numerous international agreements signed by the regime, though there was no evidence of the junta following through on its commitments, a condition that set back any potential for adaptation or environmental progress. Domestic laws and statements were drafted, and in some cases passed, though enforcement was often lacking. In the waning years of the SPDC, however, slow progress materialized, especially in the international context. Required international documents, such as the NAPA were initiated, and though in many cases follow-through by the government was severely late, it appeared that the military regime's attitudes had changed.

Environmental policy under the SLORC began with the National Commission for Environmental Affairs (NCEA). According to Myanmar's Environmental Performance Assessment (EPA) Report, "until 1989, no governmental agency existed to oversee environmental matters."¹²⁵ In 1989, the Ministry of Foreign Affairs (MOFA) was selected as the governmental agency to oversee domestic environmental protection and regulation. This was followed up by the creation of the NCEA in 1990, a new government institution within MOFA to focus solely on Myanmar's environmental protection. As part of the MOFA bureaucracy, NCEA was charged with implementing policy, while MOFA, at the higher level, reserved the right to enter into international environmental treaties. The NCEA, however, was limited in its effectiveness in implementing new laws. It was underfunded and was not given the power to enforce the new regulations. The lack of enforcement power in the agency combined with a lack of staff and funding—approximately US\$12,000 in the 2004-2005 fiscal year—prevented any meaningful environmental reform in the country and clarified where the NCEA rated within the government.¹²⁶ It was not until much later in the SLORC/SPDC period, 2005, that the NCEA was transferred from MOFA to the Ministry of Forestry, a section of the government much more appropriate for an institution tasked with domestic environmental protection.

Four subdivisions existed within the NCEA's environmental management structure, including divisions for pollution control, natural resource conservation, training and research, and international relations. Despite the continued lack of funds and enforcement power, NCEA had formulated a few notable policies that highlighted environmental issues and provided legal recommendations for future development. Though there were no domestic laws in Myanmar dealing specifically with climate change, related policies and programs had been introduced; the NCEA's meager

¹²⁵ Myanmar's National Commission for Environmental Affairs, *Myanmar: National Environmental Performance Assessment (EPA) Report* (Bangkok, Thailand: GMS Environmental Operations Center, 2008), 62.

¹²⁶ BEWG, *Burma's Environment: People, Problems, Policies*, 18.

accomplishments included Myanmar's 1994 National Environmental Policy, Agenda 21-Myanmar, and the National Environmental Performance Assessment (EPA) Report.¹²⁷

Developed in 1994, Myanmar's National Environmental Policy provided guidelines on environmental protection, specifically within the framework of economic growth and development. As an early SLORC law, however, it appeared to address economic policy and resource rights as much as it did environmental conservation. The policy states:

The wealth of the nation is its people, its cultural heritage, its environment and its natural resources. The objective of Myanmar's environmental policy is aimed at achieving harmony and balance between these through the integration of the environmental considerations into development process to enhance the quality of the life of all its citizens. Every nation has the sovereign right to utilize its natural resources in accordance with its environmental policies; but great care must be taken not to exceed its jurisdiction or infringe upon the interests of other nations. It is the responsibility of the state and every citizen to preserve its natural resources in the interests of present and future generations. Environmental protection should always be the primary objective in seeking development.¹²⁸

Though the new policy claimed to address environmental responsibility, there were no specific mandates to direct development in an environmentally sustainable way. Additionally, there were no enforcement mechanisms in place to ensure compliance. Despite these shortcomings, environmental activists within NCEA were able to use the 1994 environmental document as a building block for future policies that would prove more effective.¹²⁹

Tangible progress in domestic environmental law continued to prove elusive in the early SLORC years. Many SLORC laws were passed in the early 1990s, though they were often extremely weak, unenforced, or even unenforceable. For example, the Forest Law of 1992 opened logging to Thai and Chinese companies, which operated with

¹²⁷ Myanmar's NCEA, *Environmental Performance Assessment*, 62–64.

¹²⁸ The Burma Environmental Working Group [BEWG], *Burma's Environment: People, Problems, Policies* (Chiang Mai, Thailand: Wanida Press, 2011), 19.

¹²⁹ *Ibid.*

impunity under the protection of the new military regime. According to Peter Gutter, the wording of the Forest Law, “to implement the forestry policy of the Government ... [and] to develop the economy of the State,” resulted in a policy that “protect[ed] the timber industry instead of the forest.”¹³⁰ Indeed, the heart of the SLORC/SPDC years from 1990—2005 witnessed a decrease in overall national forest cover by approximately 18 percent.¹³¹ The Forest Law’s failure to protect the natural environment became even more obvious following the destruction of Cyclone Nargis in 2008. Nearly 140,000 people were killed by the disaster in Myanmar, mostly as a result of the massive storm surge. A post-disaster case study by the UN Environmental Program estimated that 80 years of poor environmental policy, including the previous 20 years under the SLORC/SPDC, had led to an approximate 75 percent reduction in the protective mangrove forest along Myanmar’s coast, exacerbating the effects of the storm.¹³² In addition to the ineffectiveness of such often unenforced laws, there was an absence of regulation in other environmental areas. No laws were passed under the SLORC governing air or water pollution by individuals or industry. Furthermore, laws that were passed were left to be enforced by individual ministries within the government, lacking coordination or national backing.¹³³

The most prominent international treaty signed by the SLORC was the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC came into being as one of the three major agreements to come out of the 1992 Earth Summit in Rio de Janeiro, Brazil, along with the UN Convention to Combat Desertification (UNCCD) and the UN Convention on Biological Diversity (UNCBD). As world leaders in Rio recognized the growing challenge of climate change following the 1990 first assessment report of the IPCC, the UNFCCC was drafted as a first step in confronting the

¹³⁰ Peter Gutter, “Environment and Law in Burma,” *Legal Issues on Burma Journal* 9 (August 2001), http://www.ibiblio.org/obl/docs/LIOB09-environment_and_law_in_burma.htm.

¹³¹ Claire Salisbury, “Myanmar Faces New Conservation Challenges as it Opens Up to the World,” *Mongabay*, October 4, 2013, <http://news.mongabay.com/2013/1004-salisbury-myanmar-new-conservation-challenges.html>.

¹³² United Nations Environment Programme, *Learning From Cyclone Nargis: Investing in the Environment for Livelihoods and Disaster Risk Reduction* (Nairobi, Kenya: United Nations Environment Programme, 2009), 1–12.

¹³³ Gutter, “Environment and Law in Burma.”

issue from an international political standpoint; there are now 195 signatories to the Convention.¹³⁴ With the newest information available on how the changing climate can have adverse impacts, the UNFCCC was drafted, agreed upon, and signed with the overall stated goal to “stabilize greenhouse gas concentrations ‘at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system,’” and that “such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.”¹³⁵ To achieve these goals, an extensive institutional structure was put in place to focus on various areas within the Convention, including those dealing with mitigation, adaptation, financing, and enforcement.

When the UNFCCC was adopted by the UN in 1992, it was merely a first step for the international community to agree that climate change was a serious problem that demanded the attention of all nations. As an initial step, no specific demands were made of any nation regarding climate change mitigation or adaptation, though it was determined that industrialized nations must lead the way and assist developing nations with funding, a measure that was sure to interest the SLORC. Myanmar’s government signed the treaty in 1992 and fully ratified it in 1995, generally along a similar timeline to other nations. This accomplishment for the nation was short lived, as further agreements were signed, only to see implementation and ratification delayed.¹³⁶

Many areas of focus within the UNFCCC are applicable to Myanmar under the international agreement, and the government is required to provide reports on their progress and policies, specifically those related to mitigation and adaptation. Drafted and agreed upon in 1997 as the international community recognized that specific targets for

¹³⁴ “Background on the UNFCCC: The International Response to Climate Change,” The United Nations Framework Convention on Climate Change, accessed June 15, 2014, http://unfccc.int/essential_background/items/6031.php.

¹³⁵ First Steps to a Safer Future: Introducing The United Nations Framework Convention on Climate Change, The United Nations Framework Convention on Climate Change, accessed June 15, 2014, http://unfccc.int/essential_background/convention/items/6036.php.

¹³⁶ United Nations Framework Convention on Climate Change, “First Steps to a Safer Future: Introducing the United Nations Framework Convention on Climate Change,” accessed November 15, 2014, http://unfccc.int/essential_background/convention/items/6036.php.

greenhouse gases (GHG) were essential to reduce future climate change and its impacts, the Kyoto Protocol is the most prominent international agreement in force to date. Divided into two groups based on level of development, countries are bound to take action to measure GHG emissions and for developed countries, to meet average emissions targets in future years. Specifically, developed, industrialized countries (also called Annex 1 countries) were bound to decrease GHG emissions to five percent below 1990 levels during the 2008-2012 period, and 18 percent below these levels in the 2013-2020 timeframe.¹³⁷ Myanmar, as a member of the non-annex 1 group, was not bound to these levels. As one of the lowest emitters worldwide, however, Myanmar is still responsible for measuring and reporting its yearly emissions.

As a least developed country (LDC), Myanmar is required to provide reports on climate change adaptation measures. In return for UN funds, under the LDC funding program, Myanmar had prepared and submitted a National Adaptation Program of Action (NAPA). These requirements were established under the Cancun Adaptation Framework, and aimed specifically to help developing countries, with assistance from developed nations, to determine priorities, attain technological and financial assistance, and develop national institutions to combat the adverse effects of climate change.¹³⁸

In addition to the UNFCCC, Myanmar became party to many other international treaties concerning climate change and the environment. The most important were Agenda 21 and the Rio Declaration (1992), the Vienna Convention and Montreal Protocol (1993), and the Kyoto Protocol (1997). Other important treaties included the UNCBD (1993), the International Tropical Timber Agreement (1994), the Convention on International Trade in Endangered Species of Wild Fauna and Flora, or CITES (1997), and the Agreement on ASEAN Energy Cooperation (1997).¹³⁹ These international agreements required Myanmar to act in accordance with global standards concerning

¹³⁷ Kyoto Protocol, The United Nations Framework Convention on Climate Change, accessed June 15, 2014, http://unfccc.int/kyoto_protocol/items/2830.php.

¹³⁸ Overview, The United Nations Framework Convention on Climate Change, accessed June 15, 2014, <http://unfccc.int/focus/overview/items/7879.php>.

¹³⁹ The Burma Environmental Working Group, "Advocating for Sustainable Development in Burma," August 9, 2012, <http://bewg.org/en/news/111-bewg-sd>.

environmental regulation. The Vienna Convention and Montreal Protocol set limits on ozone depleting emissions, and Agenda 21, though not technically a treaty, is a non-binding agreement on sustainable development. Clearly, the new regime in Myanmar was quick to sign on to many treaties dealing with climate change and the environment.

Simply signing on to multinational treaties did not produce tangible results, however, especially in the early years of the SLORC. Of all the international treaties signed by the SLORC/SPDC, few made any specific demands on the government to enforce policy commitments. The Kyoto Protocol under the UNFCCC, for example, only required Myanmar to measure its GHG emissions and did not make any demands, as a non-Annex 1 developing country, for reductions. Myanmar gained international recognition for being signatory to the agreement and gained the benefits that accompany it, but aside from tracking their numbers, they were not forced to make any domestic policy changes. The Montreal and Vienna Conventions on ozone protection made strong demands and required enforcement measures to ensure harmful emissions were not released into the atmosphere, and as party to these agreements, Myanmar gained legitimacy as a country serious about global environmental concerns. A closer look, however, reveals that the nation did not have any operating industries that actually emitted these gasses, and therefore the SLORC benefited without having to take any action. As a final example, the UNCBD states that nations must act “as far as possible and as appropriate” to protect flora and fauna, but also allows nations to retain “the sovereign right to exploit their own resources pursuant to their own environmental policies,” a clearly weak mandate that required no effective changes.¹⁴⁰

The next positive step in environmental policy for Myanmar came in 1997. In that year, the Ministry of Conservation and Forestry (MOECF) established a dry zone greening project. This project aimed to protect the dry zone region from continued deforestation, loss of biodiversity, and soil erosion while establishing safer and more abundant water sources for the rural areas of the region. Despite ongoing deforestation in other areas of the country, progress through the establishment of the dry zone greening

¹⁴⁰ Gutter, “Environment and Law in Burma.”

project showed that the SLORC/SPDC government was beginning to understand the country's environmental concerns and their detrimental effect on the people, and perhaps for the first time, initiate tangible action to remedy the situation. This project is still in effect and constitutes one of six departments in MOECAF.¹⁴¹

Later in 1997, the UNFCCC's Kyoto Protocol was established, and despite the progress made earlier in the year, Myanmar's government was slow to respond. Though many nations had immediately signed on to the agreement, and though Myanmar's requirements under the treaty were to be minimal, the government did not ratify the Kyoto Protocol until 2003. By this time, over 100 other nations had already done so, including many other developing nations in the region such as Vietnam, Cambodia, Laos, and Bangladesh.¹⁴² Myanmar's ratification did come, however, before the treaty was to enter into force in 2005.

Following the ratification of the Kyoto Protocol, the SPDC regime began to take greater steps to comply with their international agreements after failing to do so in previous years. The government, in 2007 began working closely with the UN to develop its NAPA to climate change, the previously discussed document necessary to secure development funding. With initial steps beginning in 2007, the document was slow to be finalized. The destruction of Cyclone Nargis in 2008 delayed processing of this publication, but also made clear how necessary its development and implementation was. Perhaps the cyclone, along with the political changes occurring at the time, caused delays, but the NAPA's initiation by the SPDC allowed for its completion by the new government, and its final publication in 2012. The same year, the first full year of the post-SPDC regime, witnessed the publication of Myanmar's Initial National Communication required under the UNFCCC and Myanmar's first report of GHG data, another reporting requirement under the Kyoto Protocol. Though these key reports were

¹⁴¹ Union of Myanmar Ministry of Environmental Conservation and Forestry, "Dry Zone Greening Department," accessed November 15, 2014, <http://www.moecaf.gov.mm/userpage2.aspx?mid=26>

¹⁴² United Nations Framework Convention on Climate Change, "Status of Ratification of the Kyoto Protocol," accessed November 15, 2014, http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php.

first submitted by many nations by the late 1990s, Myanmar's eventual compliance had shown an evolution in its regard for climate change and environmental policies.¹⁴³

By 2009, with the new constitution in force as it prepared for upcoming democratic elections in 2010, the government, under the NCEA and with assistance from the UN and other international organizations, published its National Sustainable Development Strategy (NSDS). Written as part of agreements reached under the UN program Agenda 21 and with funding assistance from the international body, the NSDS laid out programs and guidelines for future development and how climate change and the environment must be considered. Despite claims in the document that “climate change is the defining issue of our era and we need transformative actions to reverse the trends of unsustainable development,” there are no substantial recommendations made to mitigate or adapt to the challenge.¹⁴⁴ Indeed, the only objectives regarding climate change in the NSDS are vague statements regarding further research and study, and more participation in global efforts at mitigation.¹⁴⁵

Despite this transition by the SPDC in which environmental policies, climate change adaptation measures, and international treaties, there was no overnight transformation. Even with the dry zone greening project underway and with the initial steps being taken to comply with NAPA and INC reporting, the SPDC government continued to take business friendly economic action that failed to protect the environment. Environmental impact assessment requirements were not yet conducted and deforestation throughout much of the country continued. Furthermore, the regime continued making foreign business deals that would grow the economy while failing to protect Myanmar's natural environment. An agreement between the SPDC and the Chinese government on a major oil and gas pipeline led to construction beginning in 2010 without an environmental impact assessment (EIA); these pipelines have been

¹⁴³ United Nations Framework Convention on Climate Change, “Non-Annex 1 National Communications,” accessed November 15, 2014, http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php.

¹⁴⁴ Myanmar's NCEA, *National Sustainable Development Strategy for Myanmar* (Myanmar: Ministry of Forestry and United Nations Environmental Programme, 2009), ii.

¹⁴⁵ *Ibid.*, 24–25.

completed and stretch from the west coast of Myanmar, directly through the country, connecting the Bay of Bengal with southwest China, destroying forested areas and bringing numerous other environmental hazards.¹⁴⁶ In another joint project with China, the SPDC in 2009 signed an agreement on the Myitsone Dam, a hydroelectric power project to take place in Kachin State. Again, no EIA was conducted and the proposed dam sparked severe opposition nationwide. The Myitsone Dam was to be one of the largest in the world, standing at nearly 500 feet high and with a reservoir estimated at approximately 300 square miles, flooding the river plain to the detriment of the local population and the region's natural biodiversity. This project agreement was halted in 2012, however, when the new president Thein Sein recommended to parliament that the project be suspended, citing the will of the people.¹⁴⁷

D. CURRENT STATE OF CLIMATE CHANGE ADAPTATION AND ENVIRONMENTAL LAW

The slow progress of the SLORC/SPDC regime produced few tangible environmental protection mechanisms during its time in power, though its eventual transformation laid a framework for the country to build on after Thein Sein became president in 2011. Myanmar is still poorly prepared to face the challenges of climate change. Despite the low state of preparedness, however, recent action by the government has positioned the country to rectify the situation as it currently stands. New laws have been passed that target environmental protection, including an environmental conservation law and a draft environmental impact assessment law, both structured under the new government. Finally, Myanmar's National Adaptation Program of Action (NAPA) was published for the UN in 2012; this document explicitly states areas in need

¹⁴⁶ Pipelines International, "The Pipelines Feeding China's Burgeoning Economy," March 2011, http://pipelinesinternational.com/news/the_pipelines_feeding_chinas_burgeoning_economy/055358/; Shwe Gas Movement, Corridor of Power: China's Trans-Burma Oil and Gas Pipelines (Chiang Mai, Thailand: Shwe Gas Movement, 2009), 25–27.

¹⁴⁷ Kachin Development Networking Group, "Resisting the Flood: Communities Taking a Stand Against the Imminent Construction of Irrawaddy Dams," October 2009, <http://burmariversnetwork.org/images/stories/publications/english/ResistingtheFlood-1.pdf>, 3–5; BBC, "Burma Dam: Work Halted on Divisive Myitsone Project," September 30, 2011, <http://www.bbc.co.uk/news/world-asia-pacific-15121801>.

of climate change adaptation improvement and specifies which governmental agencies are tasked with their implementation.

1. Environmental Conservation Law

In 2012, the government of Myanmar passed an environmental conservation law. Over 10 years in the drafting, the new law directs the Ministry of Conservation and Forestry (MOECAF) to establish an environmental conservation committee (ECC) to carry out the provisions of the law. Under the law, the ECC is required to implement policies, make national and regional plans for environmental conservation, enact quality standards, manage and implement international environmental agreements, and enact quality controls.¹⁴⁸ Unlike environmental laws of the past, the 2012 environmental conservation law specifies direct action to be taken, consolidates environmental regulation under one defined authority, determines budget sourcing, and prescribes penalties for noncompliance. Furthermore, it stipulates that the ECC manage these programs to comply with international treaties and environmental agreements, many of which had been signed under the SLORC/SPDC and unfulfilled. As written, the 2012 environmental conservation law shows great progress over policies of the past.¹⁴⁹

2. Environmental Impact Assessment

Also in 2012, following the passage of the environmental conservation law, a new law requiring an environmental impact assessment (EIA) was drafted. The EIA has not been formally passed through the legislature, though accounts of business groups claim that the EIA is being treated by MOECAF as de facto national law.¹⁵⁰ The draft EIA states that

¹⁴⁸ Union of Myanmar, The Environmental Conservation Law: The Pyidaungsu Hluttaw Law No. 9/2012 [Myanmar's ECL], 2012, http://www.burmalibrary.org/docs15/2012-environmental_conservation_law-PH_law-09-2012-en.pdf.

¹⁴⁹ Myanmar's ECL; The Burma Environmental Working Group, "Update: The Environmental Conservation Law (March 30, 2012)," accessed November 13, 2014, <http://bewg.org/en/pubs/finish/12/63>.

¹⁵⁰ Edwin Vanderbruggen, "Myanmar Regulates Environmental Compliance for Investment Projects: Client Briefing Note—20 March 2014," VDB-Loi, http://www.vdb-loi.com/wp-content/uploads/2014/04/Environmental-compliance-for-investment-projects_VDB-Loi-Client-Briefing-Note_20March14.pdf.

There shall be established a system of environmental impact assessment which shall require any proposed project or business...in Myanmar by any ministry, government department, corporation, board...company...enterprise, firm or individual likely to have a significant impact on the environment to obtain approval for its implementation in accordance with these rules.¹⁵¹

This draft law requires all projects and business activity to be conducted by individuals, corporations, or the government to submit to an initial environmental impact estimate, and if necessary, a more formal and stringent impact assessment.¹⁵² This type of requirement is standard in many countries, but has been lacking in Myanmar. Though it has not passed as a formal law, the presence of a draft and the de facto implementation of this regulation shows Myanmar's recent shift toward serious environmental policy. Formal passage of this law, and the opportunity it provides for public comment and scrutiny, will further advance the country's ambitions regarding environmental protection.

3. National Adaptation Program of Action

The environmental conservation law and the draft EIA provide the new government of Myanmar greater opportunities for implementing sustainable environmental policies, and the NAPA, published in 2012, paves the way for direct action on climate change adaptation. As required by the UN Framework Convention on Climate Change (UNFCCC), the government of Myanmar, as a least developed country (LDC), has produced and submitted a National Adaptation Program of Action (NAPA) to Climate Change. This report is intended for the least developed nations "to identify priority activities that respond to their urgent and immediate needs to adapt to climate change—those for which further delay would increase vulnerability and/or costs at a later stage," according to the UNFCCC.¹⁵³ In Myanmar, the responsibility for producing this document was assigned to the National Environmental Conservation Committee (NECC),

¹⁵¹ Union of Myanmar, "Draft—Environmental Impact Assessment Rules," 2012, http://www.burmalibrary.org/docs15/2013-03-draft_eia_rules-en.pdf.

¹⁵² Ibid.

¹⁵³ "National Adaptation Programmes of Action," United Nations Framework Convention on Climate Change, accessed June 16, 2014, http://unfccc.int/national_reports/napa/items/2719.php.

as the NCEA was renamed under the shuffle of institutions under the newly elected government. Based on the UNFCCC requirements, the NAPA was developed with four distinct objectives in mind: to describe how Myanmar will be impacted by climate change; to formulate and prioritize the main sectors for adaptation; to guide development projects; and to make these findings public in order to increase community resilience.¹⁵⁴ The NAPA, as a post-SLORC/SPDC document, shows how much more seriously the new government is treating the issue of climate change. For example, in its preparation process, it highlights the importance of public comment and consultation as it identifies areas of vulnerability and prospective adaptation measures.¹⁵⁵ Such measures were rare under the military regime, and therefore less effective and less likely to be implemented; this shows a shift toward political accountability under the new government.

Development of the NAPA's priority adaptation projects was based on five strategies. Taken together, these strategies provide a tangible framework for future action that could better prepare the nation for the threats posed by climate change. These strategies include: "(1) Create adaptive capacities for responding to climate change impacts focused on preparedness, monitoring, pilot projects and restoration of natural capital...(2) Support the country's aim to reduce greenhouse gas emissions...(3) Integrate climate change management...(4) Increase climate change research including assessing future climate risks and current vulnerability...[and] (5) Mainstream climate change adaptation onto policy, planning and relevant projects to ensure scaling up of climate change adaptation across the country."¹⁵⁶ The strategies outlined in the NAPA, taken together, are broad and thorough. They do, however, expose how little had actually been done regarding adaptation and preparation measures under the SLORC/SPDC. By recognizing the need to create capacity for adaptation, share information, and begin to integrate the measures into future project planning, the NAPA reveals that the government is now just taking the beginning, basic steps in the adaptation process.

¹⁵⁴ Myanmar's NECC, "Myanmar's NAPA," 36.

¹⁵⁵ *Ibid.*, 37.

¹⁵⁶ *Ibid.*, 37–38.

Following the strategies outlined above, the NAPA identifies and prioritizes 32 specific measures within eight categories (four each) that the government should focus on to prepare for the effects of climate change. The list below outlines the major areas where the people and the natural environment of Myanmar are most susceptible to the effects of climate change, and therefore must focus adaptation efforts. By doing so, the government can best address potential problems progressively by adapting to areas of concern before they become immediate problems. Addressing these adaptation measures early would allow for maximum effectiveness and efficiency. Furthermore, the document identifies the location and objectives of each project, as well as an estimated budget. The NAPA describes the eight main sectors identified for climate change adaptation projects as, in priority order, “i) Agriculture, ii) Early Warning Systems, iii) Forest, iv) Public Health, v) Water Resources, vi) Coastal Zone, vii) Energy and Industry, and viii) Biodiversity.”¹⁵⁷ Listed as the most essential are the first three—agriculture, early warning systems, and forest resources (see Figure 6). Finally, the NAPA, as opposed to earlier reports on environmental governance, explores areas that could prove to be barriers to implementation of their recommendations, as well as ways to address these barriers.

Overall, the NAPA is a thorough document that provides specific details on which Myanmar should focus its climate change adaptation efforts. It addresses public input and transparency, and names agencies responsible for project implementation. Though it does expose how far behind the country has fallen in recent decades with the previous regime’s failures to enact environmental legislative commitments, it also is a strong effort at taking the first step in the adaptation process.

¹⁵⁷ Myanmar’s NECC, “Myanmar’s NAPA,” 36.

Sector/Theme	Priority Adaptation Project Title
FIRST PRIORITY LEVEL SECTORS: Agriculture, Early Warning Systems and Forest	
AGRICULTURE	First priority: Enhanced rice production through farm mechanisation and breeding new rice varieties to ensure food security in areas most vulnerable to climate change.
	Second priority: Increased climate change resilience of rural and subsistence farmers in the Dry and Hilly Zones through legume crop diversification and climate-resilient varieties.
	Third priority: Increasing the climate change resilience of Dry Zone communities by diversifying and intensifying home-gardens through solar-power technology, high-income fruit crops and climate-smart agriculture approaches.
	Fourth priority: Reducing the vulnerability of livelihoods in agro-ecological zones to climate change through the transfer of a wide range of high-yielding and climate-resilient rice varieties.
EARLY WARNING SYSTEMS	First priority: Improving weather observation capacity through a mobile/deployable weather radar system for providing early warning systems against extreme weather events.
	Second priority: Developing a flood early warning system for reducing the vulnerability of local communities to climate change impacts.
	Third priority: Assessing the hydrological impact of climate change on river systems.
	Fourth priority: Developing a drought early warning system for reducing the vulnerability of local communities to climate change impacts.
FOREST	First priority: Building the resilience of degraded/sensitive forest areas to climate change impacts through reforestation.
	Second priority: Community-based reforestation for climate-resilient ecosystems and rural livelihoods in degraded watershed areas of the Central Dry Zone.
	Third priority: Community-based mangrove restoration for climate-resilient ecosystems and rural livelihoods in vulnerable and degraded coastal regions.
	Fourth priority: Enhancing the climate change resilience of rural livelihoods through community-based restoration at the Indawgyi and Inle Lake watershed areas in the Northern Hilly Region.

Figure 6. Myanmar's NAPA: First Priority Sectors and Projects¹⁵⁸

4. Project Funding

In the past three years, as the new government has enacted political liberalization policies on a national level, Myanmar has qualified for and received funding from various sources to implement climate change adaptation measures and environmental programs. These funds were largely unavailable under the SLORC/SPDC as the state was viewed unfavorably by the international community and subject to various sanctions. As the SPDC relinquished power in 2011, however, sanctions were eased and Myanmar qualified for grants, loans, and other assistance from outside sources. The Asian Development Bank has been working with the government of Myanmar since at least mid-2012, approving 33 different projects to assist the country in development, including projects relating to irrigation, power distribution, and renewable energy.¹⁵⁹ As a result of

¹⁵⁸ Myanmar's NECC, "Myanmar's NAPA," 36.

¹⁵⁹ Asian Development Bank, "Project Records," accessed November 13, 2014, <http://adb.org/projects/search/21303%2C501?keyword=myanmar>.

Myanmar's NAPA submission to the UN in 2012, UN funding under the UN Development Program (UNDP) has become available. A major UNDP-funded project, the "Environment, Climate Change, Energy, and Disaster Risk Reduction Project," has been the source of over US\$20 million to enact specific measures highlighted by the country's NAPA.¹⁶⁰

E. CONCLUSION

The new government in Myanmar under President Thein Sein has shown concern for climate change and environmental matters in a way that is likely to produce significant progress for the country in future years. Currently, the country is not prepared for climate change's coming effects, but is positioned to progress quickly in that regard if there is continued support from the government. Myanmar has evolved in climate action policy since the beginning of the SLORC era in 1988. Taking over from an isolationist government, the SLORC recognized that environmental concerns posed a challenge to the country, but were also dealing with economic issues that they prioritized. As the regime maintained its political power through the 1990s and into the 2000s, compliance to international commitments regarding environmental policy were met, though often belatedly. As the regime handed power to the Thein Sein government in 2011, this trend accelerated, and Myanmar, though still behind in climate change adaptation, found itself in position to make rapid progress. It remains to be seen if this policy direction will be sustained, though early indications appear that it is likely.

¹⁶⁰ United Nations Development Program, "Environment, Climate Change, Energy, and Disaster Risk Reduction Project: Summary," accessed November 13, 2014, http://www.mm.undp.org/content/myanmar/en/home/operations/projects/environment_and_energy/environment--climate-change--energy-and-disaster-risk-reduction-.html.

V. CONCLUSIONS AND IMPLICATIONS

This thesis has analyzed climate change in Myanmar by examining the projected impacts to the natural environment of the country, how those impacts would affect the nation's population, and finally, what steps the state has taken to adapt to the coming changes. This paper set out to answer three questions: 1) How vulnerable is Myanmar to the effects of climate change; 2) What does this mean to the people of the country; and 3) What steps have been taken to prepare for these effects? This chapter will begin by drawing conclusions to each of these questions based on the findings of this thesis, and will conclude by discussing climate change mitigation in Myanmar, a topic that, though it has not been applicable to the country to date, will undoubtedly play a role in the coming decades.

A. MYANMAR'S CHANGING CLIMATE

National observations in Myanmar have shown that the climate has already been changing in recent decades with higher temperatures and an altered monsoon season interrupting traditional precipitation patterns. Climate modeling and the IPCC projections show that it is quite likely that Myanmar will experience an overall increase in temperature through the rest of this century, though to a lesser degree than the global average. Related to the temperature increase, precipitation rates and intensity will increase, dry season droughts will be extended, and sea levels around the coast will rise. The IPCC projections have shown that the climate in Myanmar will be affected differently in various regions of the country, with precipitation as the most variable element. A shorter monsoon season will prolong the dry periods in the country, while warmer air and sea surface temperatures will cause increased precipitation intensity in the shorter wet season. Agreement among climate models and the consistency of their results make it clear that Myanmar is vulnerable to climate change. Occupying land in the Earth's lower latitudes, however, makes Myanmar less likely to experience the more extreme changes that will affect the polar regions of the globe. Despite the lower degree of change the country will face based on latitudinal location, its geographic position does

indeed make it highly susceptible to its impacts. The long coastline, low-lying delta regions, and mountainous inland terrain increase Myanmar's vulnerability to rising sea levels, intense storms and their associated water surges, extensive droughts, and flooding due to increased precipitation intensity.

B. VULNERABLE POPULATION

Higher temperatures, precipitation rates, and sea levels will negatively impact the livelihoods of Myanmar's people by straining the agriculture sector, decreasing the year-long supply of clean fresh water, spreading disease, and increasing the risk of damage from cyclones and other natural disasters. With approximately 70 percent of the population dependent on agriculture, variations in temperature and precipitation could have catastrophic effects. Higher temperatures in an already warm region will affect rice production unless significant changes to production methods are implemented. Extensive droughts in the dry seasons, especially in the dry region of the country, will further stress agriculture, as will flooding due to intense rains in the wet season. Warming temperatures will increase the spread of disease by extending the range of vector-borne illness, and the alternating droughts and floods will negatively impact sanitation measures in populated areas. The negative impacts of climate change on Myanmar's people will be exacerbated by the relative poverty in the country and its lack of infrastructure. Economic growth is necessary to blunt these impacts, and Myanmar has not yet reached a sufficient level of development to make a significant difference.

C. ADAPTATION AND PREPAREDNESS

The negative impacts to Myanmar's people and environment could be offset to a large degree by effective government action regarding climate change adaptation and environmental policy, and though steps have been recently taken in that direction, Myanmar is still quite unprepared to deal with this new environment. Climate change became a global issue in the late 1980s and early 1990s, at precisely the time the SLORC was taking over the government of Myanmar. The regime was, in the early years, occupied with internal ethnic conflict and economic growth, and therefore gave little consideration to serious environmental policy or climate change adaptation. To provide

national economic benefits, the SLORC opened the country to foreign resource extraction companies, which paid little attention to environmental sustainability, and entered into international agreements on the environment and climate change to secure international legitimacy and foreign funding for the state. As time passed and the government matured, more attention was given to the issue. A dry zone greening project was implemented in 1997, and administrative restructuring in 2005 transferred the National Commission for Environmental Affairs from the Ministry of Foreign Affairs to the Ministry of Forestry. Furthermore, the SLORC/SPDC initiated efforts to produce documents required by UN treaties, including the NAPA, the National Sustainable Development Strategy, and the Initial National Communication on climate change. These late-SLORC/SPDC efforts laid the foundation for the new government under President Thein Sein to address climate change adaptation and environmental policy in a substantial way. Ultimately, Myanmar's successive governments have failed to adequately prepare the country for the impending effects of climate change; if, however, the implementation measures outlined in these documents, in conjunction with their associated laws and programs, are carried out and enforced, Myanmar has the opportunity to make significant progress in the years ahead.

D. FUTURE CONCERNS AND IMPLICATIONS

One aspect of climate change that has not been thoroughly discussed is mitigation. This aspect has been purposely neglected in the body of the thesis because of Myanmar's negligible GHG emissions, though there are certain implications to consider for the country's future. The rest of this chapter will discuss climate change mitigation in Myanmar, specifically regarding the country's global impact and possible actions it can take in future years.

Myanmar made its initial national communication, as required under the Kyoto Protocol, to the UNFCCC in 2012. As an underdeveloped nation, and therefore a non-annex 1 party, it was not required to make binding cuts to GHGs, but was required to track and account for its emissions. Using the year 2000 as a baseline, Myanmar's contribution to global GHG emissions was very low in relation to other nations,

especially considering the existence of carbon sinks and overall forested area, which absorb emissions from the atmosphere. Myanmar's contribution to global GHGs was a net negative because of its carbon absorption, resulting in a removal of 67,820 gigagrams (Gg) of carbon dioxide equivalent (CO₂e) from the atmosphere.¹⁶¹ Positive contributions of CO₂e came from the agricultural, industrial, energy, waste, and forestry sectors of the economy (see Figure 7). Despite its growing economy, Myanmar still has a low impact on positive contributions, ranking as only the 97th highest country in the world in CO₂e emissions as of 2013 with approximately 10 million tons, according to the Global Carbon Atlas.¹⁶² As Myanmar's economy develops further, however, and its manufacturing and industrial sectors grow, its contribution to global GHGs is likely to rise. Developmental assistance and funding from the international community could help offset the potential impacts if modern and efficient technologies are transferred to Myanmar as it develops, and renewable energy standards prevent the overreliance on fossil fuels.

Source / Sink	CO ₂ Removal	CO ₂ Emission	CO	CH ₄	N ₂ O	Nox	CO ₂ Equ. Total Emission	CO ₂ Equ. Net Emission
Energy Sector		7,658.65	-	5.62	0.28	-	7,863.47	7,863.47
Industry Sector		248.59	-	-	-	-	463.29*	463.29
Agriculture Sector			0.81	963.75	8.4	0.022	22,843.67	22,843.67
(a)Agriculture			0.81	507.25	8.2	0.022	13,195.17	13,195.17
(b)Lives tock				456.5	0.2		9648.5	9648.5
Forestry Sector	142,221.20	33,656.51	2,215.37	144.85	4.26	34.08	40,404.73	-101,816.50
Waste Sector				134.57			2,825.97	2,825.97
TOTAL	142,221.20	41,563.75	2,216.18	1,248.79	12.94	34.102	74,401.13	-67,820.10

Figure 7. GHG Emissions and Removals in Myanmar: 2000¹⁶³

¹⁶¹ Myanmar's MOECAAF, *Myanmar's INC*, iii.

¹⁶² Global Carbon Atlas, Global Carbon Project, accessed November 19, 2014, <http://www.globalcarbonatlas.org/?q=en/emissions>.

¹⁶³ Myanmar's MOECAAF, *Myanmar's INC*, iii.

The government of Myanmar has an opportunity to promote development in a sustainable way that is healthy for the economy and for the climate. The Initial National Communication (INC) to the UN expressed views on development and climate issues that suggest a desire to proceed along these lines, as it mentions climate change mitigation measures that will have a positive effect on the nation as it grows. Specifically, the INC discussed options for progress that include changes to the energy, agriculture, forestry, and waste sectors. Because of its low state of development, Myanmar's energy sector does not produce significant GHG emissions. Somewhat surprisingly, renewable energy is more prevalent than the use of fossil fuels. In fact, according to the INC, "energy produced from hydropower and biomass shares about 67 percent of total energy consumption."¹⁶⁴ This figure can be misleading, however, as less than 30 percent of the nation's people have access to a reliable electricity source; as the nation develops and electricity becomes more widespread, renewable energy—at least at the current rate of production—is unlikely to be able to maintain such a high percentage of the total.¹⁶⁵ The government appears aware of this fact and promotes energy efficiency, reductions in fossil fuels, and increases in renewables as part of its energy strategy for the future.¹⁶⁶

As well as promoting changes in the energy sector, Myanmar's GHG emission reduction strategy incorporates changes to the agriculture, forestry, and waste sectors. Alterations in rice production methods can easily reduce GHG emissions, and educating farmers on these methods could have a significant effect in the agriculture sector. Furthermore, changes to livestock numbers, feeding, and care methods could further decrease agricultural emissions. Waste emission reductions are within reach with further community education and governmental action as well. Changes to industrial practices, municipal waste reduction, and recycling programs can have a great effect with an educated population. Finally, the forestry sector can have a significant effect on total net

¹⁶⁴ Myanmar's MOECA, *Myanmar's INC*, 5.

¹⁶⁵ The World Bank, "Power to People: World Bank Group to Invest US \$2 Billion in Myanmar to Support Reforms, Reduce Poverty, Increase Energy and Health Access," January 26, 2014, <http://www.worldbank.org/en/news/press-release/2014/01/26/world-bank-group-to-invest-2-billion-in-myanmar-to-support-reforms-and-reduce-poverty>.

¹⁶⁶ Myanmar's MOECA, *Myanmar's INC*, v.

emissions from the country. Strategies proposed by the government include changes to reduce deforestation and protect the vast natural forested areas of the country, as well as implementing reforestation practices. Protection for Myanmar's forests could ultimately be the greatest positive influence on net carbon emissions as the carbon absorption capabilities of these areas offset emissions in other areas.¹⁶⁷

Governments are often reluctant to implement climate change mitigation policies because they believe the costs are too high. Acquiring necessary technologies for efficient building and manufacturing methods can be difficult and expensive. Furthermore, renewable energy technology is, in many cases, still more costly than traditional fossil fuel energy production. Developing countries have opportunities to develop in sustainable ways, however, with the assistance of industrialized nations. The UN, World Bank, Asian Development Bank, and the Organization for Economic Cooperation and Development, among other international institutions, non-governmental organizations, and private enterprises have provided methods for developing countries to acquire the needed technologies through technology transfers and sustainable development funding. This allows countries such as Myanmar an avenue to grow and develop in a way that is environmentally sustainable and minimizes their negative impact on climate change.

Once the cost is accounted for, however, there are numerous other desirable consequences of climate change mitigation that are byproducts of their primary purpose. Sustainable growth, energy efficiency, and clean, renewable energy sources are generally better for the natural environment as a whole, resulting in cleaner air and water. Cascading effects lead further to a healthier population, biodiversity in natural habitats, and healthier food sources from clean water fisheries and agricultural land. Another significant benefit of renewable energy practices is energy security. Renewable energy is generally created in the country of use; relying on domestic renewable energy promotes economic growth and employment opportunities within the country, and decreases the reliance of foreign sources of energy such as oil and coal. Such secondary benefits of

¹⁶⁷ Myanmar's MOECA, *Myanmar's INC*, v–vi.

climate change mitigation practices create a situation that is beneficial in its own right, even without considering the mitigating impacts of climate change. As Rashid and Paul explain further, “these benefits provide a ‘no regret’ GHG emission reduction policy even if the impacts of climate change turn out to be less than that indicated by available projections.”¹⁶⁸ Myanmar stands to benefit from such practices as it develops, and funding and assistance from the international community provide it a way to proceed in a productive and responsible way.¹⁶⁹

Climate change policy decisions cannot be ignored by Myanmar’s government. The threat to the country is clear. Climate modeling and the IPCC projections show the potential dangers ahead for the nation, and disasters such as Cyclone Nargis have exemplified the possible ramifications of further inaction. Despite the difficulties that can be inherent in climate-first policies and implementing environmental regulation, the government has an opportunity to act in the best interest of the country and its people. First, the UN Climate Convention Conference schedule includes a Conference of Parties in December 2014 in Lima, Peru, to prepare for the 2015 conference in Paris where, according to the UNFCCC, “nations are committed to deliver a new universal agreement on climate change,” to act as the successor to the Kyoto Protocol.¹⁷⁰ Additionally, democratic elections are scheduled for 2015 in Myanmar. This transfer of government, if completed in a way that is accepted as free and fair by the international community, can further increase the legitimacy of Myanmar’s political liberalization in the eyes of the world, opening the country to new opportunities to interact with other nations and secure the tools necessary for future environmentally sustainable development. Myanmar’s opportunity is at hand; the next few years will be critical in determining the future of the country and its people.

¹⁶⁸ Rashid and Paul, *Climate Change in Bangladesh*, 148.

¹⁶⁹ Ibid., 148–150.

¹⁷⁰ United Nations Framework Convention on Climate Change, “Lima,” accessed November 20, 2014, <http://newsroom.unfccc.int/lima/christiana-figueres-lecture-at-the-stiftung-mercator-foundation/>.

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

- “Asthma, Respiratory Allergies, and Airway Diseases.” Centers for Disease Control and Prevention. Accessed October 9, 2014.
http://www.cdc.gov/climateandhealth/effects/airway_diseases.htm.
- Asian Development Bank. “Project Records.” Accessed November 13, 2014.
<http://adb.org/projects/search/21303%2C501?keyword=myanmar>.
- BBC. “Burma Dam: Work Halted on Divisive Myitsone Project.” September 30, 2011.
<http://www.bbc.co.uk/news/world-asia-pacific-15121801>.
- Bryant, Raymond L. “The Greening of Burma: Political Rhetoric or Sustainable Development?” *Pacific Affairs* 69, no. 3 (1996): 341–359.
<http://www.jstor.org/stable/2760923>
- The Burma Environmental Working Group. “Advocating for Sustainable Development in Burma.” August 9, 2012. <http://bewg.org/en/news/111-bewg-sd>.
- . “Update: The Environmental Conservation Law (March 30, 2012).” Accessed November 13, 2014. <http://bewg.org/en/pubs/finish/12/63>
- Center for International Earth Science Information Network. *Low Elevation Coastal Zone (LECZ) Urban-Rural Population and Land Area Estimates*, Version 2. Palisades, NY: National Aeronautics and Space Administration Socioeconomic Data and Applications Center, 2013. Accessed May 15, 2014.
<http://sedac.ciesin.columbia.edu/data/set/lec2-urban-rural-population-land-area-estimates-v2>.
- Chew-Hung Chang. “Preparedness and storm hazards in a global warming world: lessons from Southeast Asia.” *Natural Hazards* 56 (March 2011). doi: 10.1007/s11069-010-9581-y.
- “Climate Change: Basic Information.” U.S. Environmental Protection Agency. Accessed December 16, 2013. <http://www.epa.gov/climatechange/basics/>.
- “Climate Change: Basic Information.” National Aeronautics and Space Administration. Accessed May 18, 2014. <http://climate.nasa.gov/scientific-consensus>.
- Cline, William R. *Global Warming and Agriculture: Impact Estimates by Country*. Center for Global Development: Washington, DC, 2007.
- “Cyclone Nargis.” Burma Center Prague. Accessed May 6, 2014. <http://www.burma-center.org/en/burma/history/cyclone-nargis/>.

- Defense Science Board Task Force. *Trends and Implications of Climate Change for National and International Security*. Washington, DC: Department of Defense, 2011.
- “Flooding Threat Adds to Woes of IDP’s in Myanmar’s Rakhine State.” *IRIN News*. July 7, 2014. <http://www.irinnews.org/report/100313/flooding-threat-adds-to-woes-of-idps-in-myanmar-s-rakhine-state>.
- “Global Carbon Atlas.” Global Carbon Project. Accessed November 19, 2014. <http://www.globalcarbonatlas.org/?q=en/emissions>.
- “Global Climate Change.” National Aeronautics and Space Administration. Accessed May 18, 2014. <http://climate.nasa.gov/scientific-consensus>.
- “Greater Mekong Subregion Atlas of the Environment.” 2nd ed. Asian Development Bank. December 2012. <http://www.adb.org/sites/default/files/pub/2012/gms-atlas-environment-2nd-edition.pdf>.
- Gutter, Peter. “Environment and Law in Burma.” *Legal Issues on Burma Journal* 9 (August 2001). http://www.ibiblio.org/obl/docs/LIOB09-environment_and_law_in_burma.htm.
- Hijioka, Yasuaki, Erda Lin, and Joy Jacqueline Pereira. “Asia.” In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects*, ed. Rosa Perez and Kazuhiko Takeuchi. Cambridge and New York: Cambridge University Press, 2013. Accessed November 6, 2014. http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap24_FGDall.pdf.
- Human Rights Watch. “All You Can Do is Pray: Crimes Against Humanity and Ethnic Cleansing of Rohingya Muslims in Burma’s Arakan State.” April 2013. http://www.hrw.org/sites/default/files/reports/burma0413webwcover_0.pdf.
- International Panel on Climate Change. *Climate Change 2007: Synthesis Report*, edited by R.K. Pachauri and A. Reisinger. Geneva, Switzerland: IPCC, 2007.
- . *Climate Change 2013: The Physical Science Basis*, edited by T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley. Cambridge and New York: Cambridge University Press, 2013.
- “IPCC Frequently Asked Question 3.2: How is Precipitation Changing?” UN International Panel on Climate Change. Accessed September 10, 2014. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-3-2.html.
- “IPCC History.” UN International Panel on Climate Change. Accessed August 27, 2014. http://www.ipcc.ch/organization/organization_history.shtml.

- “IPCC Members Grouped According to WMO Regions.” UN International Panel on Climate Change. Accessed August 27, 2014. <https://www.ipcc.ch/pdf/ipcc-principles/ipcc-countries.pdf>.
- “IPCC Organization.” UN International Panel on Climate Change. Accessed August 27, 2014. <http://www.ipcc.ch/organization/organization.shtml>.
- Kachin Development Networking Group. “Resisting the Food: Communities Taking a Stand Against the Imminent Construction of Irrawaddy Dams.” October 2009. <http://burmariversnetwork.org/images/stories/publications/english/ResistingtheFood-1.pdf>.
- Kreft, Sönke, and David Eckstein. “Global Climate Risk Index 2014.” Germanwatch e.V. November 2013. <http://germanwatch.org/de/download/8551.pdf>.
- Marks, Danny. “Climate Change and Thailand: Impact and Response.” *Contemporary Southeast Asia* 33, no. 2 (2011). http://www.academia.edu/2047244/Climate_Change_and_Thailand_Impact_and_Response.
- Myint, Tun. “Environmental Governance in the SPDC’s Myanmar.” In *Myanmar: The State, Community, and the Environment*, edited by Monique Skidmore and Trevor Wilson, 189–217. Canberra: ANU E Press and Asia Pacific Press, 2007.
- Nai, Aye. “Heatwave kills 230 in Mandalay.” *Democratic Voice of Burma*, May 20, 2010. <http://www.dvb.no/news/heatwave-kills-230-in-mandalay/9091>.
- “National Adaptation Programmes of Action.” United Nations Framework Convention on Climate Change. Accessed June 16, 2014. http://unfccc.int/national_reports/napa/items/2719.php.
- Pipelines International. “The Pipelines Feeding China’s Burgeoning Economy.” March 2011. http://pipelinesinternational.com/news/the_pipelines_feeding_chinas_burgeoning_economy/055358/.
- Rashid, Harun, and Bimal Paul. *Climate Change in Bangladesh: Confronting Impending Disasters*. Lanham, MD: Lexington Books, 2014.
- Salisbury, Claire. “Myanmar Faces New Conservation Challenges as it Opens Up to the World.” *Mongabay*. October 4, 2013. <http://news.mongabay.com/2013/1004-salisbury-myanmar-new-conservation-challenges.html>.
- Selth, Andrew. “Even Paranoids Have Enemies: Cyclone Nargis and Myanmar’s Fears of Invasion.” *Contemporary Southeast Asia* 30, no.3 (2008): 379–402.

- Shwe Gas Movement. *Corridor of Power: China's Trans-Burma Oil and Gas Pipelines*. Chiang Mai, Thailand: Shwe Gas Movement, 2009.
- Than, Tin Maung Maung. "Myanmar: Preoccupation with Regime Survival, National Unity, and Stability." In *Asian Security Practice: Material and Ideational Influences*, edited by Muthiah Alagappa, 390-416. Stanford: University Press, 1988.
- "Union of Myanmar Agricultural Atlas." Food and Agriculture Organization of the United Nations. Accessed December 5, 2014.
http://dwms.fao.org/atlas/myanmar/downs/atlas/p013_political_map.pdf.
- Union of Myanmar: Department of Meteorology and Hydrology. *Hazard Profile of Myanmar*. Nay Pyi Taw: Union of Myanmar, 2009.
- Union of Myanmar Department of Population. *Population and Housing Census of Myanmar, 2014: Provisional Results*. Nay Pyi Taw: Department of Population, 2014. http://www.dop.gov.mm/wp-content/uploads/2012/12/Census_Provisional_Results_2014_ENG1.pdf.
- Union of Myanmar. "Draft—Environmental Impact Assessment Rules." 2012.
http://www.burmalibrary.org/docs15/2013-03-draft_eia_rules-en.pdf.
- . "The Environmental Conservation Law: The Pyidaungsu Hluttaw Law No. 9/2012." 2012. http://www.burmalibrary.org/docs15/2012-environmental_conservation_law-PH_law-09-2012-en.pdf.
- Union of Myanmar Ministry of Environmental Conservation and Forestry. "Dry Zone Greening Department." Accessed November 15, 2014.
<http://www.moecaf.gov.mm/userpage2.aspx?mid=26>.
- Union of Myanmar Ministry of Conservation and Forestry. *Myanmar's Initial National Communication (INC) Under the United Nations Framework Convention on Climate Change*. Nay Pyi Taw: Ministry of Conservation and Forestry, 2012.
- Union of Myanmar Ministry of Health. *Myanmar Health Statistics 2010*. Accessed October 9, 2014.
<http://www.moh.gov.mm/file/Myanmar%20Health%20Statistics%202010.pdf>.
- Union of Myanmar: National Environmental Conservation Committee, Ministry of Environmental Conservation and Forestry. "Myanmar's National Adaptation Programme of Action (NAPA) to Climate Change." 2012.
<http://unfccc.int/resource/docs/napa/mmr01.pdf>.

- United Nations Development Program. "Environment, Climate Change, Energy, and Disaster Risk Reduction Project: Summary." Accessed November 13, 2014. http://www.mm.undp.org/content/myanmar/en/home/operations/projects/environment_and_energy/environment--climate-change--energy-and-disaster-risk-reduction-.html.
- United Nations Environment Programme. *Learning From Cyclone Nargis: Investing in the Environment for Livelihoods and Disaster Risk Reduction*. Nairobi, Kenya: United Nations Environment Programme. 2009.
- United Nations Framework Convention on Climate Change. "First Steps to a Safer Future: Introducing the United Nations Framework Convention on Climate Change." Accessed November 15, 2014. http://unfccc.int/essential_background/convention/items/6036.php.
- . "Lima." Accessed November 20, 2014. <http://newsroom.unfccc.int/lima/christiana-figueres-lecture-at-the-stiftung-mercator-foundation/>.
- . "Non-Annex 1 National Communications." Accessed November 15, 2014. http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php
- . "Status of Ratification of the Kyoto Protocol." Accessed November 15, 2014. http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php.
- United States Central Intelligence Agency. "The World Factbook." Accessed May 15, 2014. <https://www.cia.gov/library/publications/the-world-factbook/geos/bm.html>
- United States Environmental Protection Agency. "Climate Change Indicators in the United States: Tropical Cyclone Activity." Accessed September 14, 2014. <http://www.epa.gov/climatechange/science/indicators/weather-climate/cyclones.html>.
- Vanderbruggen, Edwin. "Myanmar Regulates Environmental Compliance for Investment Projects: Client Briefing Note—20 March 2014." VDB-Loi. http://www.vdb-loi.com/wp-content/uploads/2014/04/Environmental-compliance-for-investment-projects_VDB-Loi-Client-Briefing-Note_20March14.pdf.
- Win, Kyay Mohn. "Mandalay Rainfall Down 12.6 Percent in 2009." *Myanmar Times*, August 24, 2009. <http://www.mmtimes.com/index.php/national-news/6160-mandalay-rainfall-down-12-6-percent-in-2009.html>.
- The World Bank. "Power to People: World Bank Group to Invest US \$2 Billion in Myanmar to Support Reforms, Reduce Poverty, Increase Energy and Health Access." January 26, 2014. <http://www.worldbank.org/en/news/press-release/2014/01/26/world-bank-group-to-invest-2-billion-in-myanmar-to-support-reforms-and-reduce-poverty>.

World Health Organization. *World Malaria Report 2010*. Accessed October 9, 2014.
http://whqlibdoc.who.int/publications/2010/9789241564106_eng.pdf?ua=1.

Yergin, Daniel. *The Quest*. New York: Penguin Books, 2012.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
Ft. Belvoir, Virginia
2. Dudley Knox Library
Naval Postgraduate School
Monterey, California