Environmental Issues in East Asia

EA30e Spring 2021

May 15, 2021

Contents

Preface

0.1 Guiding Principles

Environmental issues in East Asia are not unique or particularly more prevasive than other parts of the world. However, the issues are born from particular histories that may contrast with other parts of the world and other parts of the world may be able to learn from.

In this project, the students in EA030e (Spring 2021) have written a textbook that highlights examples of environmental processes. Each student contributed to one theme, composed of two examples that highlight environmental issues of East Asia.

0.1.1 Context and Positionality

As students in a college course located in Southern California, we approach the project with...

Our goal is not to call out environmental issues in East Asia, but to point to linkages of how a range of globalized economy contribute to these environmental problems.

In the end, it would be useful for us to acknowledge we have some capacity to address these how these global linkages could be modified to reduce these environmental issues.

We are not experts, but learning... if there are errors please let us know... We recommend that suggestions be submitted via a github pull request.

0.1.2 Goals

Processes across horizontal boundaries define many environmental patterns that frame human interactions with the environment. How do humans impact processes that cross these boundaries and how do humans influence these ecosystem interface?

0.1.3 Rationale

We hope to learn more about the how environmental issues are expressed in different parts of the world and to what extent can we learn from this work.

0.1.4 Activity

Each group will be composed of two students, that will become experts and teach their classmates on the topic.

0.2 East Asia and the World

0.3 Acknowledgments

Everyone in the world!

LaTeX Guide

Why Learn LaTeX?

Creating Professional Typesetting

In the past, I used LaTeXto make publication quality text. In fact, many prefer writing in LaTeXbecause they can focus on the text and avoid worrying about formatting. However, it is NOT WYSIWYG ("what you see is what you get") word processor. In reality, the processing or compiling is a separate step.

Nevertheless, the quality of the output and ability to integrate with R (or Python) allows us to have an exceptional tool to make reproducible documents with highly professional looking typesetting.

How to Learn LaTeX?

There are several ways to learn LaTeX. I suggest you find a decent tutorial to get the basics. For example, here are some suggestions:

- Learning LaTeXin 30 minutes

If you are like me and can't remember commands very well, then here's a cheet sheet that might be helpful.

R Chunks

To create effective graphics, each chapter will have a rchunk that creates a graphic for the chapter. To review and learn R, here are some resources:

- Marc's Video Description
- RMarkdown for Scientists (super helpful!)
- R Studio Tutorial
- R Studio's Cheatsheet
- R Markdown Cookbook – Robust Source

Noting Your Contribution

Because this is an ongoing project, you should record your contribution to each chapter – but also let go of these contributions at some point; Others might revise and their authorship might take some precedence, so you should both invest in the product but also be willing to detach from the final outcome as others contribute. This will feel uncomfortable at times, but please note from the beginning this is a social process and as such subject to negotiation. Please be generous to the authors that laid the foundation and be respectful of those that follow.

0.4 Setting Up Book Project–Type Setting w/ LATEX

0.4.1 Latex Book Class

Currently, the text is written using the standard book class.

Structuring the Text with Nested Hierarchies

Contributors divide their contributions into sections and subsections. This format allows a consistent approach to structuring the text and forcing themes to be organized in blocks that can be used to organize the overall text. We use section, subsection, and subsubsection to break up the topic into bite sizes.

To accomplish this, contributors use the `\section{Section}` command for major sections, and the `\subsection{Subsection}` command for subsections, and a similar approach for subsubsections.

NOTE: for each nested level, it MUST be followed by the lowest level in the section before a paragraph is started – in contrast to what is shown above!

NOTE: We may dispense with subsubsections in the future to provide a less blocky structure, but for now they remain useful.

Font Changes

We can use various methods to alter the typeset: *Emphasize*, **Bold**, *Italics*, and *Slanted*. We can also typeset Roman, Sans Serif, SMALL CAPS, and `Typewriter` texts. Look online to see the commands to accomplish these changes.

You can also apply the special, mathematics only commands $\mathbb{BLACKBOARD}$, $\mathbb{BOLD}$, $\mathcal{CALLIGRAPHIC}$, and $\mathfrak{fraktur}$. Note that blackboard bold and calligraphic are correct only when applied to uppercase letters A through Z.

You can apply the size tags – Format menu, Font size submenu – tiny, scriptsize, footnotesize, small, normalsize, large, Large, LARGE, huge and Huge.

You can use the `\begin{quote} etc. \end{quote}` environment for typesetting short quotations. Select the text then click on Insert, Quotations, Short Quotations:

> The buck stops here. *Harry Truman*
>
> Ask not what your country can do for you; ask what you can do for your country. *John F Kennedy*
>
> I am not a crook. *Richard Nixon*
>
> I did not have sexual relations with that woman, Miss Lewinsky. *Bill Clinton*

The Quotation environment is used for quotations of more than one paragraph. Following is the beginning of description of LATEXfrom *Wikipedia*:

> LaTeX (/ËĹlÉŚËŘtÉŻx/ LAH-tekh or /ËĹleÉłtÉŻx/ LAY-tekh, often stylized as LATEX) is a software system for document preparation. When writing, the writer uses plain text as opposed to the formatted text found in "What You See Is What You Get" word processors like Microsoft Word, LibreOffice Writer and Apple Pages. The writer uses markup tagging conventions to define the general structure of a document (such as article, book, and letter), to stylise text throughout a document (such as bold and italics), and to add citations and cross-references. A TEXdistribution such as TEXLive or MiKTEXis used to produce an output file (such as PDF or DVI) suitable for printing or digital distribution.
>
> LATEXis widely used in academia for the communication and publication of scientific documents in many fields, including mathematics, statistics, computer science, engineering, physics, economics, linguistics, quantitative psychology, philosophy, and political science. It also has a prominent role in the preparation and publication of books and articles that contain complex multilingual materials, such as Sanskrit and Greek. LATEXuses the TEXtypesetting program for formatting its output, and is itself written in the TeX macro language."

Use the Verbatim environment if you want LATEX to preserve spacing, perhaps when including a fragment from a program such as:

```
#read csv data  // read data into R
my.dataframe <- read.csv(file.choose())   // read data from a popup window.

str(my.dataframe) // display data structure
```

(After selecting the text click on Insert, Code Environments, Code.)

Mathematics and Specialized Characters

Warning: Special Characters

When you use percent and ampersand symbols, hash tags, and other non-standard ASCII characters, LATEXwill be very uncooperative. LATEX doesn't like a range of characters or they reserved for special behavior. So, do yourself a favor and make sure you understand that these are used for special typesetting functions. To use them you have to "escape" and use commands to get them to do what you might usually expect!

The following symbols $, %, #, &, è, ñ, " and " do not reflect the key stroke you might expect.

For example, the & is used for tabs in a table environment. % is used to make comments, thus stuff behind a % is ignored. There are lots of others, but these come up the most. If you want to show use the ampersand or one of these characters, put a backslash in front of the dollar sybmol, e.g. \$. See Table 1.

If you want to a superscript (raised to 3nd power), we can create text in math mode, with $ to start and end the text in math mode, e.g. m^3 is written in LATEXas m$ˆ3$. A subscript uses an underscore, x$_1$ creates x$_1$. If you need more than one character as a subscript or superscript then enclose the content in curly brakets, e.g. x^{2c} (x$ˆ{2c}$) and t$_{step}$ (t$_{step}$).

Table 1: Table of Symbols in LaTeX

Symbol	LaTeXcode	Symbol	LaTeXcode
&	\&	$	\$
“	``	”	''
mg L^{-1}	mg~L^{-1}		

0.4.2 Creating equations

One of the most powerful parts of LaTeXis how it can be used to write complex equations, with all those symbols and Greek letters! This can be done inline $y = mx + b + \epsilon$ for fairly simple equations, or set apart for more complex equations:

$$\int_0^\infty e^{-x^2} dx = \frac{\sqrt{\pi}}{2} \tag{1}$$

Theorems, etc

Theorem 1 *(The Currant minimax principle.) Let T be completely continuous selfadjoint operator in a Hilbert space H. Let n be an arbitrary integer and let $u_1, \ldots, u_{n-1}$ be an arbitrary system of $n-1$ linearly independent elements of H. Denote*

$$\max_{\substack{v \in H, v \neq 0 \\ (v,u_1)=0,\ldots,(v,u_n)=0}} \frac{(Tv, v)}{(v, v)} = m(u_1, \ldots, u_{n-1}) \tag{2}$$

Then the n-th eigenvalue of T is equal to the minimum of these maxima, when minimizing over all linearly independent systems $u_1, \ldots u_{n-1}$ in H,

$$\mu_n = \min_{u_1,\ldots,u_{n-1} \in H} m(u_1, \ldots, u_{n-1}) \tag{3}$$

The above equations are automatically numbered as equation (2) and (3).

Lists Environments: Making bulletted, numbered, description lists

We use special commands to create an itemized list.

You can create numbered, bulleted, and description lists (Use the Itemization or Enumeration buttons, or click on the Insert menu then chose an item from the Enumeration submenu):

1. List item 1
2. List item 2
    (a) A list item under a list item.
    (b) Just another list item under a list item.
        i. Third level list item under a list item.
            A. Fourth and final level of list items allowed.

- Bullet item 1

- Bullet item 2
  - Second level bullet item.
    - Third level bullet item.
      - Fourth (and final) level bullet item.

Description List Each description list item has a term followed by the description of that term.

Bunyip Mythical beast of Australian Aboriginal legends.

Theorem-Like Environments

The following theorem-like environments (in alphabetical order) are available in this style.

Example 2 *This is an example*

Exercise 3 *This is an exercise*

Theorem 4 *This is a theorem*

"Child" Rnw Contributions to create a Textbook

To create the texbook, we will each contribut chapters, which are referred to in knitr speak as a 'child'. For each 'child' or chapter, will be a sepreate Rnw fild, but without the need for the preamble, such as the `\begin{document}` and `\end{document}`, which is pretty handy. Then each chapter has the exact same formatting as defined in the root document, which you have to select in the project options.

Peer Review Commenting

You can put your comments in square brackets and in color for things that need help. [This section is confusing, I am not sure what commenting means.] I have created a short cut command to do this with `\red{}`.

Adding Figures, etc

Using Rnw Files

To generate R figures, we use R chunks in and Rnw file, where the text is integreated. When we compile into a PDF, the program converts the files into TeX files and then combineds them into a single pdf.

For each chapter, we create a "child" document and Marc will help you create that text when you begin.

Creating a floating figure

This is my floating figure (Figure 1).

Figure 1: My plot's caption is here!

Using R to Create Effective Figures

R Markdown can be a very powerful tool to integrate R code, figures and text. Making high quality figures that are both clear and aestically pleasing will be something that we need to think about it.

- Axis Labels – Labelled with clarity
- Axis Text – Size, Orientation
- Captions (usually better than titles)
- References connecting labels to references
- ADA accessible (e.g. color impairment mitigation)

For example, here's an example of a pretty good figure, and you can find the code in the 01-guide.Rnw file.

In the case of Figure 2, we can a create a figure that has all of the characteristics listed above, except perhaps ADA. Creating a "alt text" for the figure is something we might want to consider – For now a decent caption about what the reader is seing is super helpful.

Using Boxes

0.4.3 minibox X Some text

Cross-References, Citations, and Glossaries

Cross-References

We can cross-reference sections (e.g. Section **??** or figures (Figure **??**) using several methods. I suggest you look at the this Rmd file to see how I did it in these examples.

You can also create links to URLs or hyperlinks, e.g. `http://texblog.org`. However, if these addresses change, then the link will break, so I suggest you only link to internal references.

Bibliography generation

There will be two steps to cite our sources. First, we need to add the reference to a database, or bib file. This is titled 'References.bib' and is located in the main folder in our respository. When you add information to the bib file, be sure to paste in the reference using a bibTeX format.

Second, we'll need to place in-line citations, using `\citep{knitr}`, which produces (Xie, 2021), by using a key, which is knitr in this case.

For example, you might write, "This document was produced in RStudio using the knitr package ((Xie, 2021)). Also try `\citet{LosHuertos2017OverviewR}` to create use the author name as the subject: Los Huertos (2018) wrote an guide to help students learn R.

Note: You will see these citations automatically put in alphabetic order in the Bibliography at the end of the PDF.

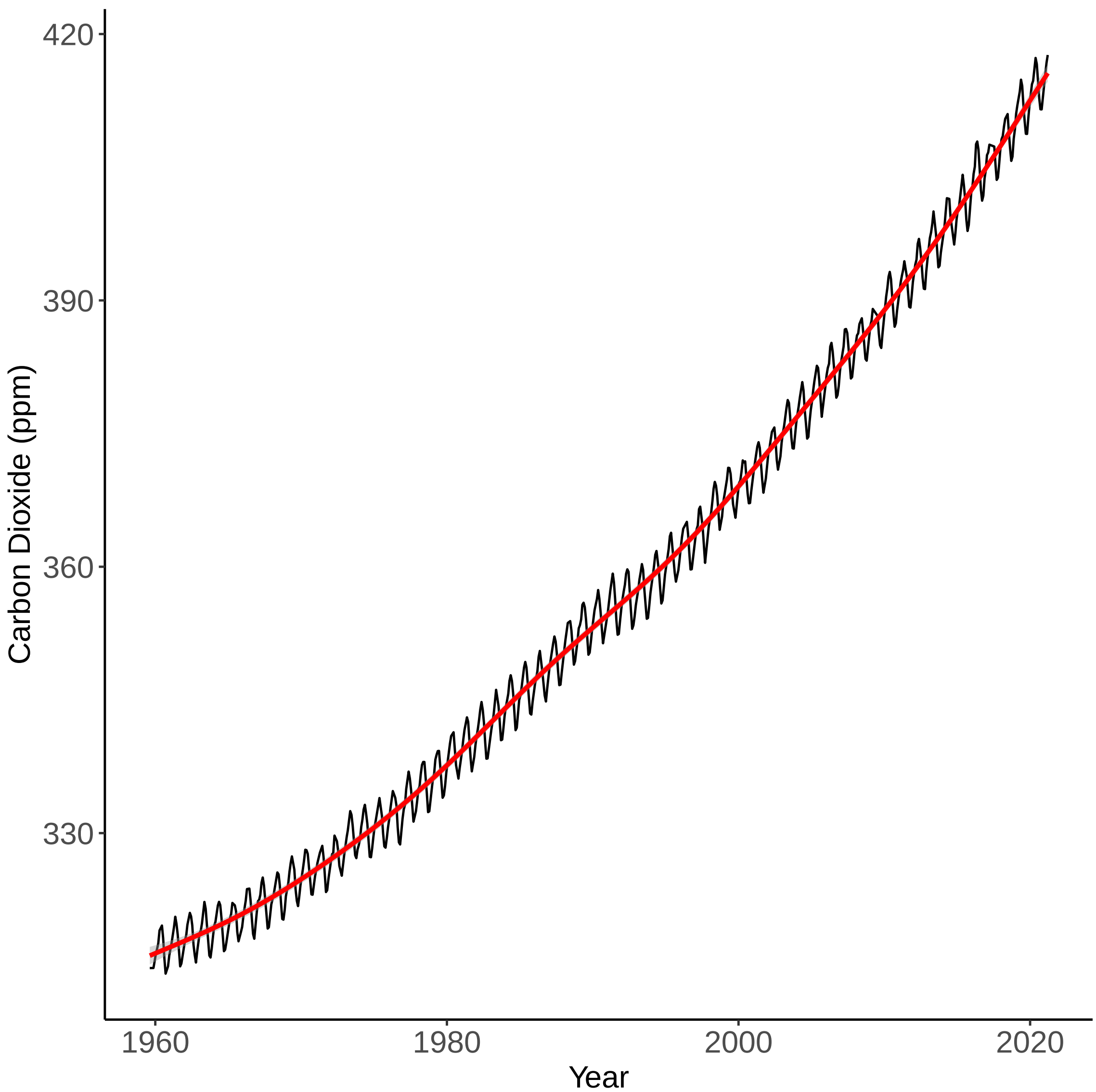


Figure 2: Carbon Dioxide Concentrations (Mauna Loa, HI). Data demonstrate the CO2 concentrations are increases, but that a seasonal impact is embedded in the long-term trend. Source: Scripps/NOAA.

Creating glossary words

Not sure why, I haven't been getting this to work yet – stay tuned!

Definition 5 *This would be used in a glossary entry at the end of the book and the word is use in an glossary, e.g.* **peat***.* **Peat** *is when you want to capitalize the defined word without having to re-define a capitalized version, the only downside of case sensitivity in LATEX.*

Custom Environments

For text that we rely on many times, but require odd key strokes and hard to remember code, we can create new commands as shortcuts.

For example, I have created two so far:
`\carbondioxide}`, CO_2
and
`\kms`, km^2

Template Chapter Title

Chapter Author

[1]

0.5 Section Heading

0.5.1 Subsection Headings

Some text here...The hierarchy structure is described in the Author Guide, Section 0.4 – NOTE: This is a section cross reference.

if you cut and paste, be sure to make sure you don't include formatted characters outside the ASCII values. See Author Guide, Section 0.4.1. NOTE: This is a subsection cross reference.

Optional Subsubsection Headings

some text here.... and a subsubsection cross reference (See Section 0.5.1).

0.6 Goals of this template

0.6.1 Learning LaTeX

This template will NOT teach you how to use LaTeX! To accomplish that, we'll rely on some great online resources that you can find on in Chapter 0.3.

Instead this section of the document is designed to demonstrate how our textbook will look, feel, and ultimately how we contribute to the project.

This document also compiles all of our projects into a single PDF, where each chapter is composed of a input tex file.

0.6.2 Placing figure

R Created Figures

First we create an R chunk and add some code. In this case, I created a floating figure which can be referenced (Figure 3)!

[1] Statement of Contributions– For example, "The chapter was first drafted by Marc Los Huertos (2021). The author recieved valuable feedback from X, and Y and Z to improve the chapter. Slater revised the chapter in 2022 with suggestions from Cater." Note: I am still working on the formatting for this to improve it.

```
plot(pressure)
```

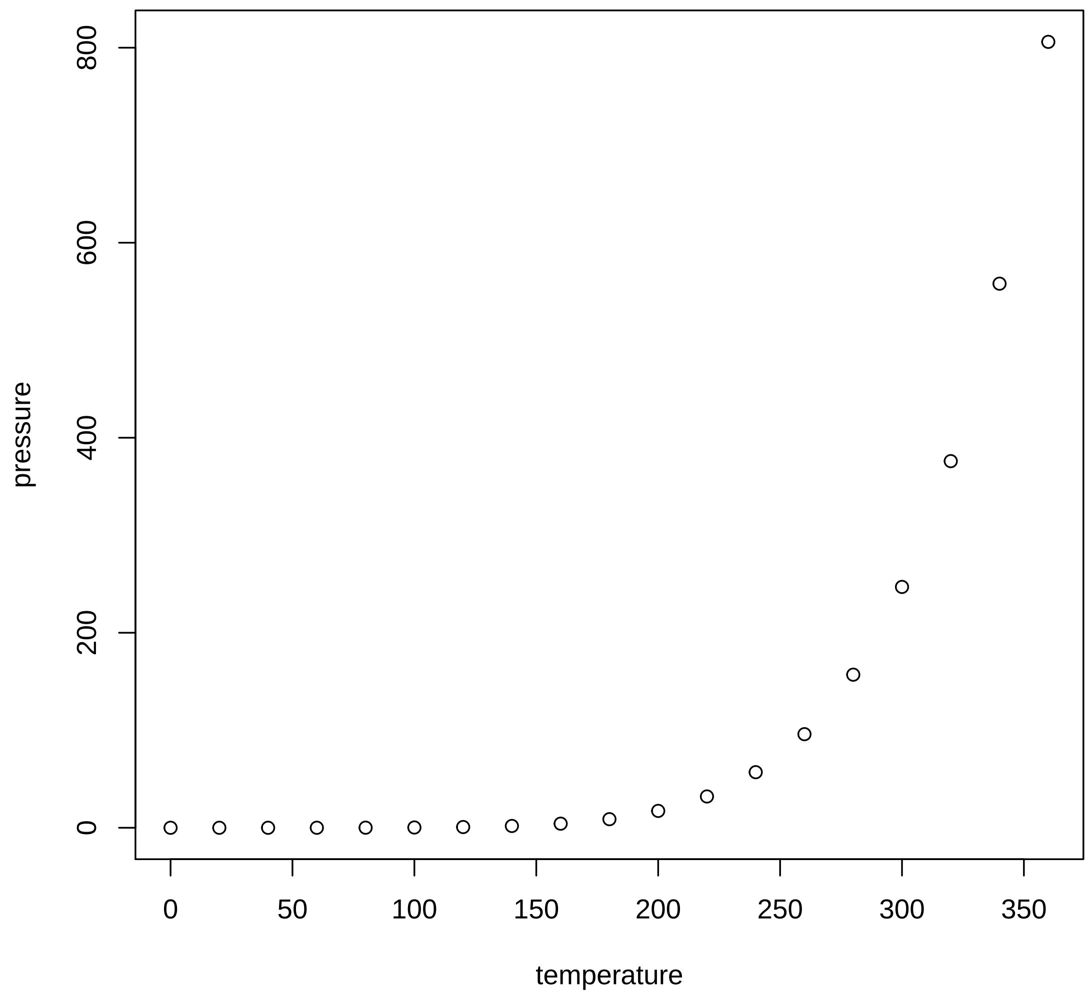


Figure 3: Figure Caption...we should turn "echo=False" in the R chunk options, but I left it true for now. (source: ??)

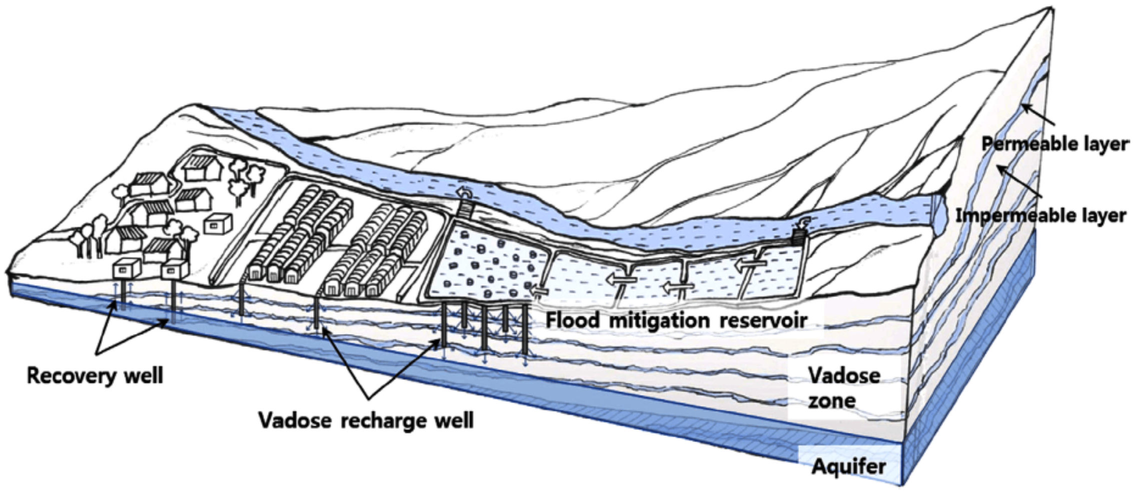


Figure 4: Vadose zone is neato (Source: Lee et al. (2017)).

Floating Figures from External Sources

All figures and images that are imported should be put into the "images" sudirectory to keep stuff organized. Even better to create a subdirectory with your images, but we can naviagate as we go.

Figure 4 is a good example of inserting an image from an external source.

In this case, I had to specify the width so it would fit on the page! See the Rnw file for the code. Notice, I was also abel to "reference" the figure in the text.

0.6.3 Adding Citations

See the Guide, as well, but my video is probably the most helpful.

Generally, there are many environmental trends in Asia (Imura et al., 2005).

Imura et al. (2005) describes the how urbanization has affected the hydrology of East Asia.

Nora's Practice Sessions

NORA

→

4/23 1. made new project titled ERTA2020-NewEA30e21-Project 2. did the single branch clone for EA30e21 3. switched the Git brach pull down to EA30e21 in remote: ORIGIN 4. testing if I can push to my branch only 5. save changes 6. commit - TEST NEW PROJECT PUSH TO BRANCH at 2:04 did it work? 2:03 est YES 2:16 est

1. added Marc's repo as the "upstream" to be able to pull from his branch when things are changed there 2. tried to fetch from marc's EA30e21 branch. - SUCCESSFUL 3. no need to use the "git merge origin EA30e21 "code 4. going to test making a pull request to Marc after saving, committing and pushing to my repo. did it work? 7:45 est YES 7:51 est

0.7 Testing Various Push and Pull Options

test commit and pull request

0.7.1 What Factors Drive Land Use Change?

Chapter 1

The Political Ecology and Economy of Rice in Myanmar

Lucas Florsheim

1.1 Introduction

As climate change becomes an increasingly concerning threat to agriculture many countries throughout Southeast Asia are rushing to adopt new agricultural practices that subvert issues like flooding and rising temperatures. According to the IPCC, Southeast Asian food production could fall by up to 30% By 2050 If certain agricultural adaptations are not implemented (Wassmann et al., 2004).Although specific agricultural adaptations and solutions differ depending on climate and region, many scientists have outlined the general changes that will need to be implemented to sustain food production in the face of the climate crisis.

Adaptive options for confronting issues related to increasing temperatures and hydrological disruption include incorporating crops that are heat-resistant and less vulnerable to salinity stress, improving water management, and altering crop management practices. Other potential options are implementing resource-conserving technologies (RCTs), diversifying crops, improving pest management, and creating better weather forecasts. (Wassmann et al., 2004). While evidence shows that these methods will indeed work to sustain agricultural production in countries throughout Southeast Asia, many of these adaptations may not be feasible implementations for developing countries with complex political structure and history.

Myanmar certainly fits the bill of having a convoluted government and political history. Since its independence from Great Britain in 1948, the country has fallen victim to several coups and has been ruled by its military for most of the last 70 years. Leading up to the Green Revolution in the 1960s, Myanmar was one of the top rice exporters in the world (Naing et al., 2008). The deltaic regions of Myanmar had an advantage over other rice producing areas as lucrative deep-water or floating rice systems were routinely utilized. Following the Green Revolution, the countryâĂŹs military government was not initially invested in implementing new agricultural methods and thus fell behind other leading rice exporters. Just as lack of infrastructure and varying priorities caused Myanmar to lose its spot as the top rice exporter in the latter half of the 20th century, these factors now actively inhibit the country from performing the necessary implementations in response to the agricultural issues posed by the climate crisis.

Myanmar has made tremendous progress towards democracy in the last 20 years. This progress culminated in a democratically elected parliament being sworn in 2016, with the elections of 2015 being the first openly contested elections since 1990. A democratically elected government is necessary to execute the sweeping agricultural adaptions and to introduce the infrastructure needed to combat the effects of climate change. Military goverments prioritize controlling the economy, which often means maintaining the status quo, even in the face of climate change. Earlier this year the military of Myanmar, led by General Min Aung Hlaing declared a national emergency and seized control of the country in the form of a coup de'etat. The military is now in sole control of the county's operations and infrastructure and has spent the last several months attempting to qual both peaceful protests and armed civilian resistance (Goldman, 2021). The overwhelming majority of Burmese people are in opposition to military governance, resulting in daily protests since the coup took place. Since the military seized power on February 1st, over 600 civilians have died at the hands of the government, and thousands more have been injured and arrested (Goldman, 2021).

Combatting the effects of climate change and ensuring food security in Myanmar through sustainable rice production is only possible if the country is politically stable. A history of political unrest and conflict inhibiting proper infrastructure and development indicates that Myanmar will struggle to adopt the agricultural adaptations that experts recommend to mitigate the environmental problems of the coming century.

In this chapter we will examine the political economy and ecology of rice in Myanmar throughout history as well as the potential climate related threats to rice production. It is through this analysis that we will attempt to understand the implications of the history of rice production in Myanmar, as well as examine the current state of MyanmarâĂŹs government as it relates to the future of the country's rice production in the era of climate change.

1.2 Climate and Rice Production

Being one of the largest countries in Southeast Asia, Myanmar experiences several different climates, varying greatly based upon region. The most northern parts of the country feature a humid subtropical climate with hot and humid summers and mild winters. The Northeastern part of the country experiences a temperate oceanic climate meaning warm summers without significant seasonal differences in precipitation. The rain-fed rice producing regions in the south of the country are in either Tropical Savanna or Monsoon climate zones. Tropical Savannah climate classifications are defined by having distinct and differing wet and dry seasons. Monsoon climates are very similar to Tropical Savanna climates, but experience significantly heavier rainfall. Precipitation and minimum and maximum temperatures not only show substantial variation across the country but are also greatly impacted by monsoons.

Temperatures are generally lower in the mountainous regions to the North, whereas the southern portion of the country is much warmer and wetter and therefore more suitable for rice production (Naing et al., 2008). Ayeyarwady, Yangon, and Bago are the three major rice growing divisions in Myanmar, all of which are in the Southern part of the country.

The Irrawaddy delta is responsible for 68% of Myanmar's rice production (Brakenridge et al., 2017). River basins and deltas are the most ideal for rice agriculture, as fertile sediment deposited by water, known as alluvial soil, is naturally provided, and monsoon rainfal is prevalent in these floodplains. (Naing et al., 2008). Rice cultivation in Myanmar relies heavily on deep-water rice production, the flooding of paddy fields that results in increased growth and higher yields.

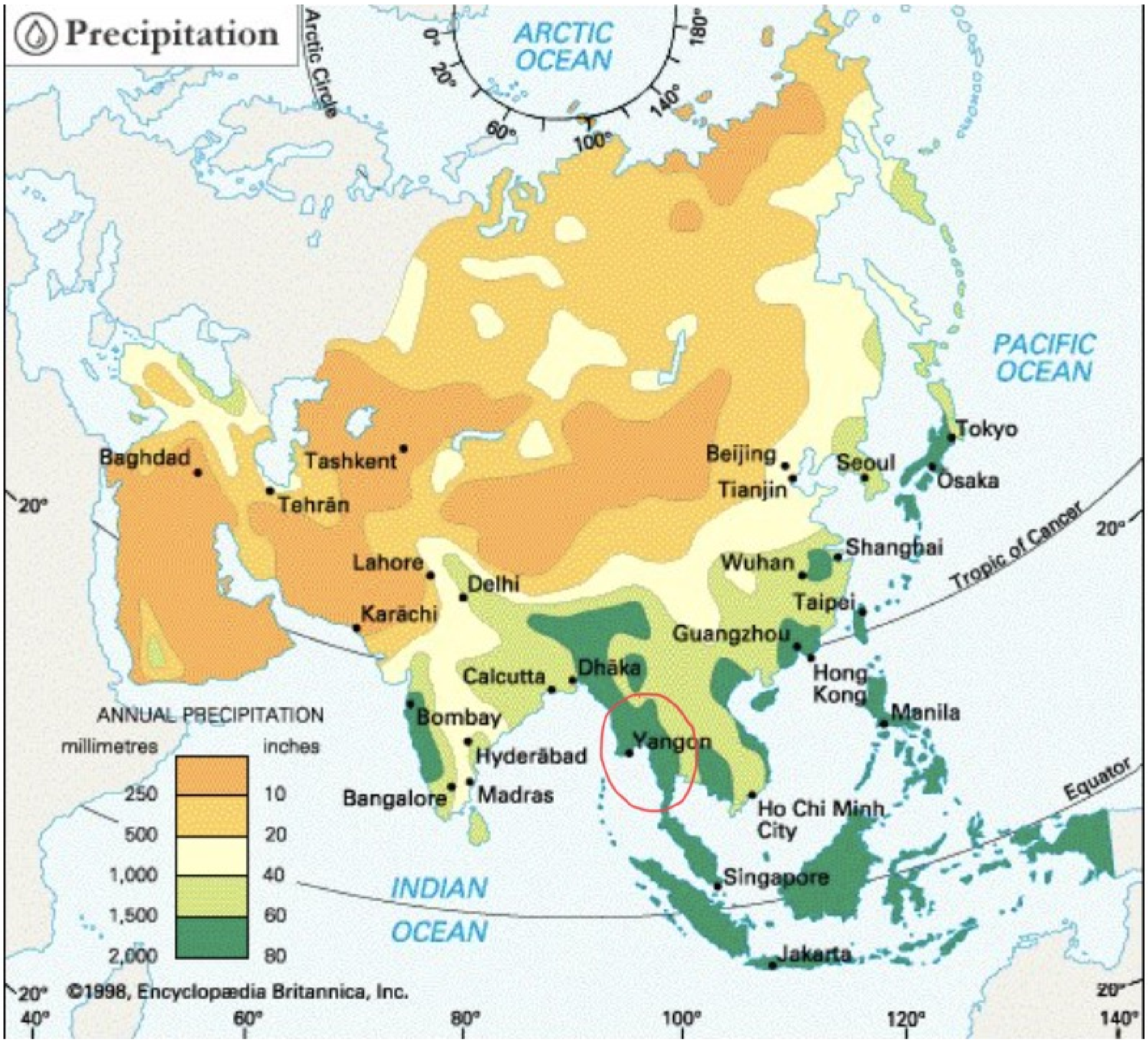


Figure 1.1: Average annual precipitation in Asia, the rainfed rice-producing region of Myanmar is circled in red.

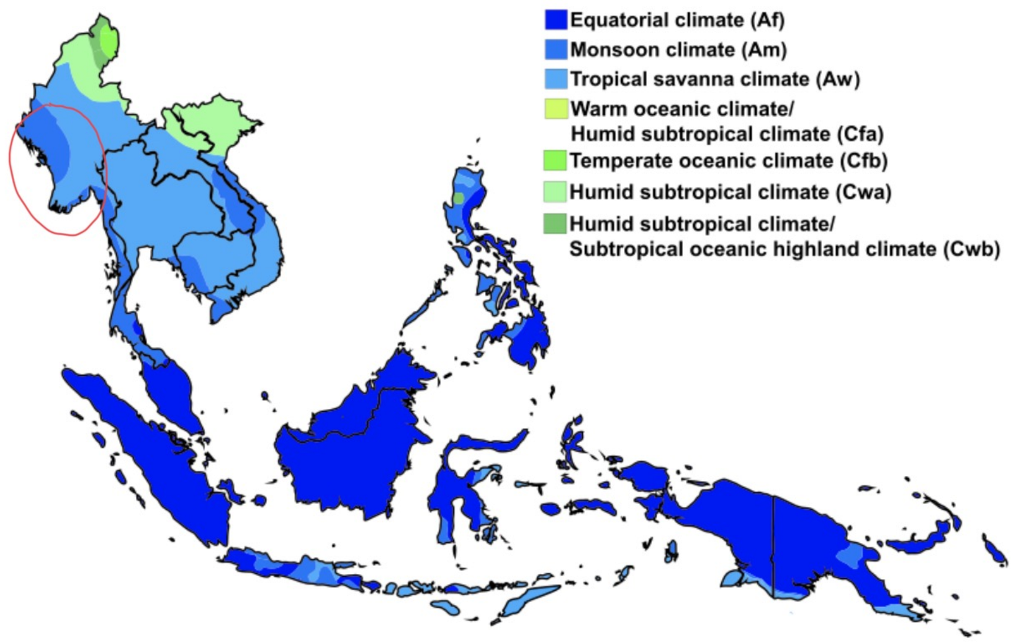


Figure 1.2: Climate Classifications of Southeast Asia, with the rice-producing region circled in red.

1.3 Agricultural Production and Food Insecurity

Jobs in food production make up over 80% of the workforce in Myanmar, 70% of these jobs are in rice production. Despite relying on an agricultural economy, Myanmar has historically struggled to feed its population. In 2019, the Myanmar Ministry of Health and Sports conducted a random sampling survey that revealed that 1 in every 3 families in Myanmar is food insecure and is facing problems related to undernutrition (Hlaing et al., 2019). Because the majority of Burmese people work in agriculture, understanding the source of economic and food insecurties of these individuals is critical. In a survey that involved 22 NGOs in Myanmar, it was concluded that hunger in agricultural communities is heavily tied to farmer's limited access to markets, land tenure rights, and lagging and ineffective agricultural environments and technology (Elkharouf and Pritchard, 2019). Many farmers live in isolated communities connected by dilapidated roads and do not own cars or have access to public transportation.This being the case, it is extremely difficult for farmers to reach sellers or traders. In addition, complicated land tenure rules often lead to disputes over agricultural land and leave loopholes for the government to seize farmland. Furthermore, the government's reluctancy to subsidize the costs quality seeds and proper agricultural technology has been economically detrimental to many farming communities.

1.4 Implications of Climate Change on Rice Production

According to the Asian Development Bank (ADB), the effects of climate change are expected to result in a decrease in rice paddy yield across all Asian sub-regions of up to 20% by 2050 (Sinnarong et al., 2019). A simulation using climate projections from Thailand's Development and Coordina-

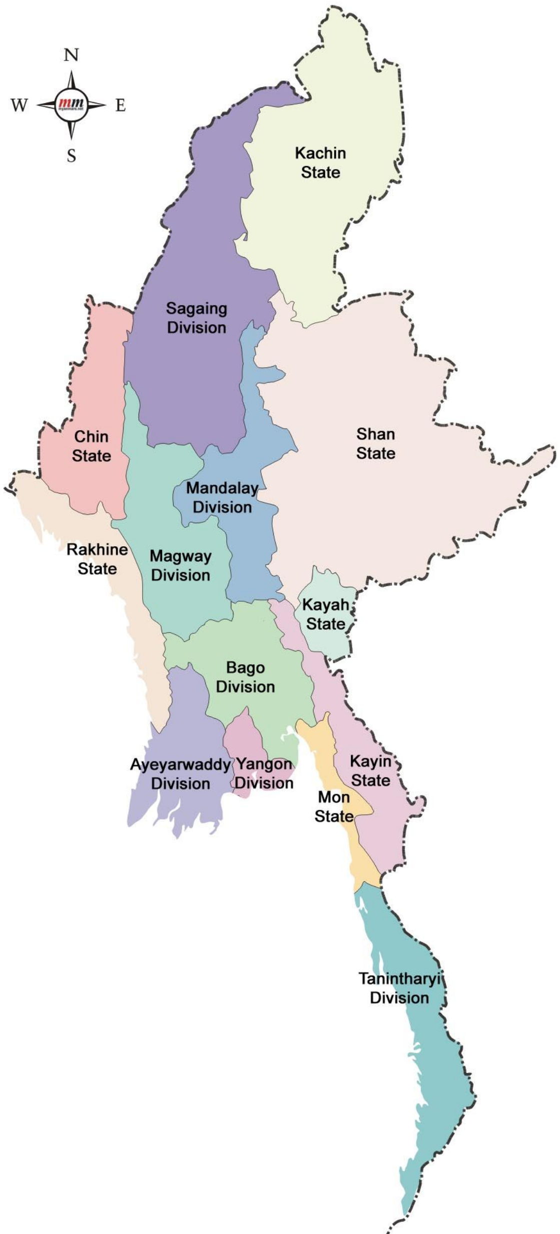


Figure 1.3: Map of regions in Myanmar

tion Center for Global Warming and Climate Change, and the Southeast Asia START Regional Center, an environmental organization founded by the National Research Council of Thailand and Chulalongkorn University, created a regional climate modelling system that could be used to predict changes in precipitation and temperature and model the subsequent consequences on the economy. This simulation, which combined macroeconomic theory and crop modeling, revealed that the fluctuations in temperature and precipitation associated with the effects of climate change ultimately result in the instability of prices of rice and other crops across 73 provinces in Thailand (Sinnarong et al., 2019). Although the model was specific to a 20 km x 20 km region in Thailand, its implications can certainly be applied to neighboring Myanmar. While the unpredictability of temperature and precipitation pose significant threats to Myanmar's agricultural economy, extreme weather and sea-level rise are also expected to have a negative effect on rice production in deltas such as the Irrawaddy River Basin (Furuya et al., 2014). In the following sections the ways in which increasing temperatures, increasing variability in precipitation patterns, and other climate change related factors have been found to decrease average rice yield will be explored.

1.4.1 Increasing Temperatures

One effect of climate change that has a significant impact on rice production is increasing temperatures. In Myanmar, the warmest months occur directly before monsoon season, from March to June. During these months, the Southern coastal regions of the country experience temperatures well above 36°Celsius (C), which is beyond the critical limits of heat tolerance for rice ((Wassmann et al., 2004)). A study conducted by Dr. Shao-Bing Peng of Huazhong Agricultural University concluded that rice yield can decrease by up to 10% for each 1°(C) increase in minimum temperatures during the dry-season, which occurs from October to May in Myanmar (Peng et al., 2004). Rising temperatures are more significant in the winter months, lasting from November to February, than in the summer as it is expected that there will be a more prominent increase in minimum temperatures than maximum temperatures annually ((Wassmann et al., 2004)).

High heat stresses rice crop during the most vulnerable periods of the plant's production cycle. The growth rate of rice increases linearly as temperatures increase from 22°C to 31°C, and then decreases significantly beyond that point ((Wassmann et al., 2004)). In the vegetative stage, the period of growth between germination and flowering, temperatures hotter than 35°C have an extremely negative affect on photosynthetic carbon fixation. At high temperatures kinetic energy increases and bonds within cellular membranes loosen which creates a reorganization of thylakoid stacks, or grana (Karim et al., 1997). This heat-induced reaction can reduce photosynthesis by over 35% (Oh-e et al., 2007).

During the reproductive stage the meristem, the tissue on the tips of roots and shoots prodcues new cells, begins producing flowers. It is during this phase when rice plants experience spikelet sterility because of high temperatures (R. (Wassmann et al., 2004)). Spikelet sterility refers to reduced fertility in florets, in this case caused by reduced pollen production as a result of increased temperatures. Regarding the ripening period, also known as grain filling, high temperatures can greatly decrease grain weight and size because of excessive energy consumption that occurs to meet increased respiratory demands that are associated with warm temperatures (R. (Wassmann et al., 2004)). As a result of negative effects that occur at multiple different stages in the production cycle of rice, rice yield can decrease by as much as 39.6% if the crop experiences temperatures above 35°C (Xiong et al., 2017).

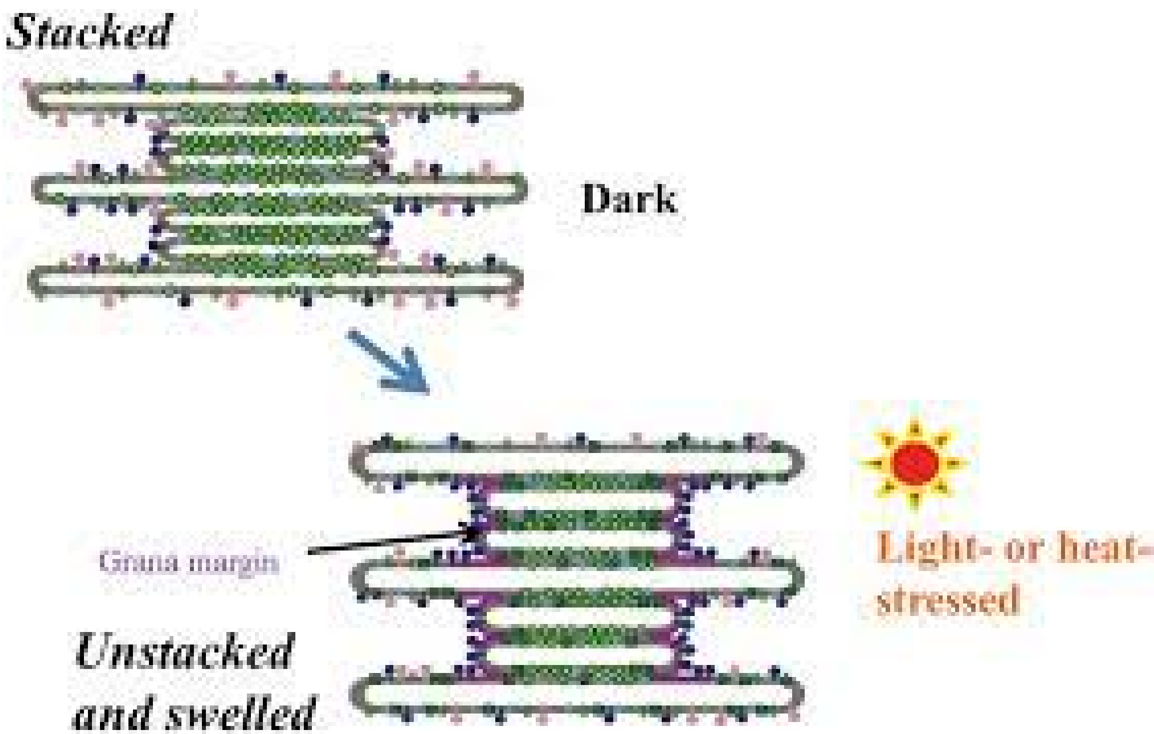


Figure 1.4: Comparison of an undisturbed (stacked) chloroplast and the swelling of the grana that is induced by heat

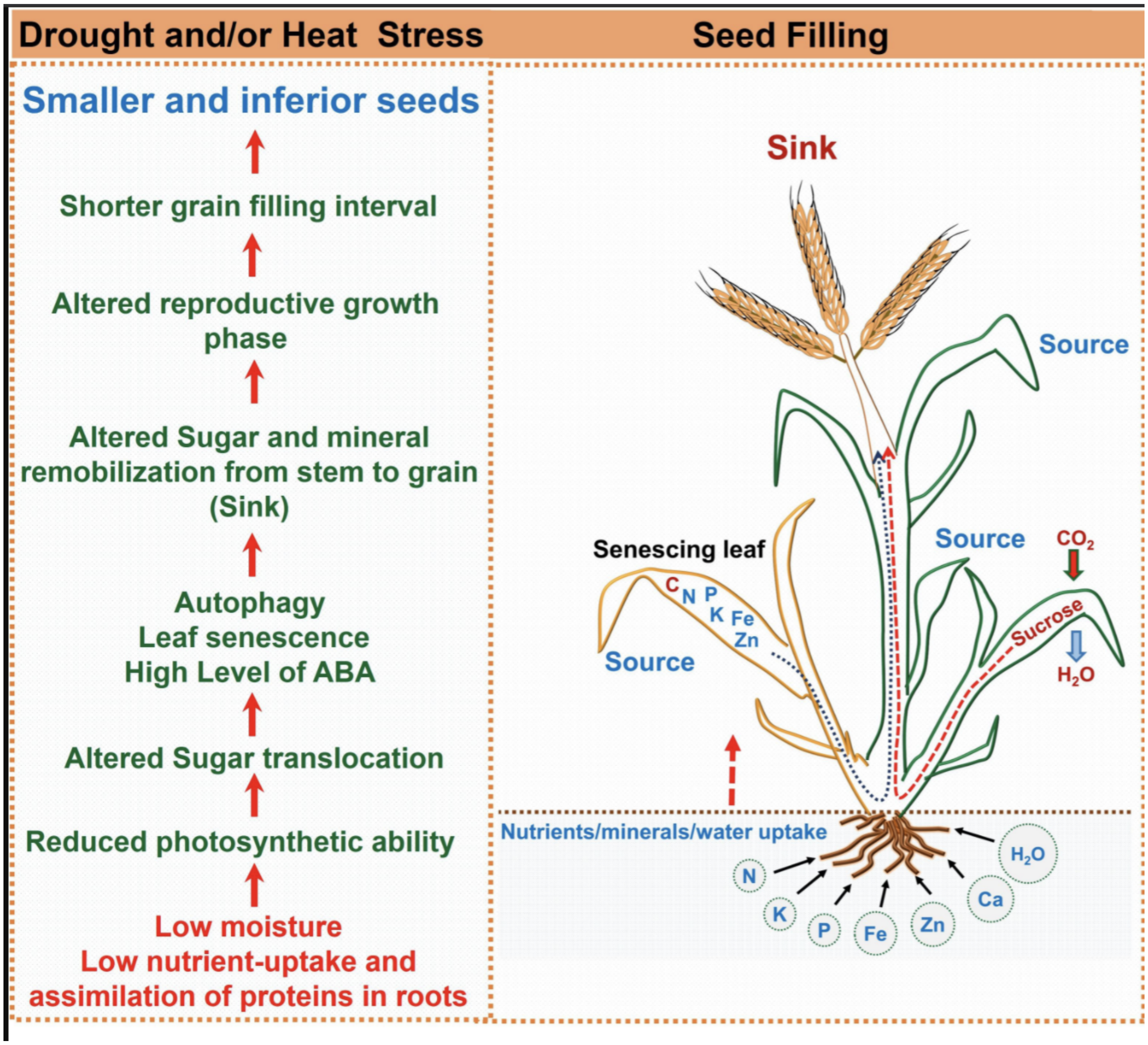


Figure 1.5: The effects of high temperature stress plant reproduction. Although high temperatures effects both male and female functions, studies show that high temperature predominantly reduces rice grain size by impairing the production of pollen (Wassmann et al., 2004).

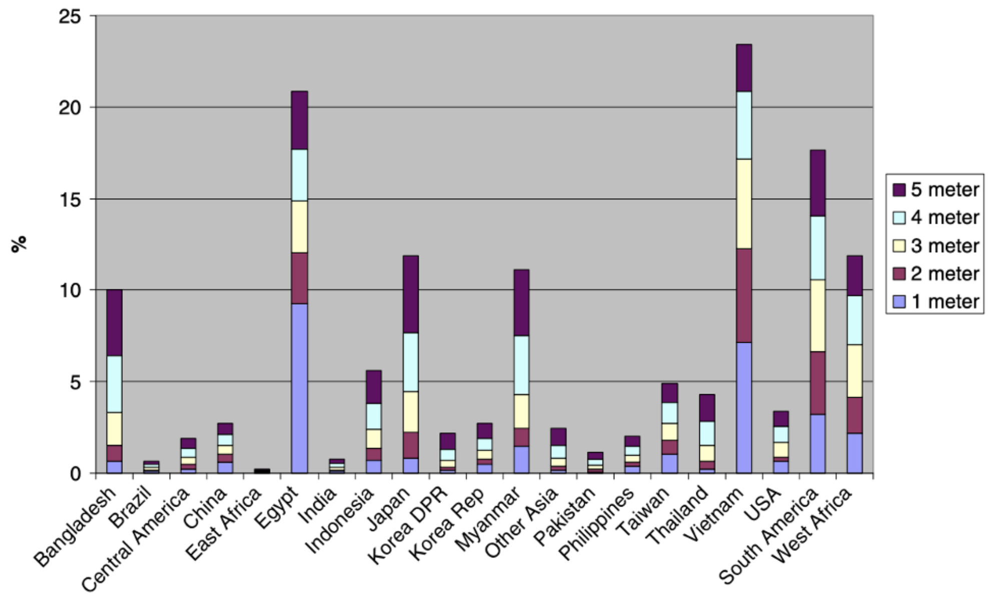


Figure 1.6: Percentage of agricultural land lost under projected SLR for a number of vulnerable countries (Chen et al., 2012).

1.4.2 Sea Level Rise

According to the National Oceanic and Atmospheric Administration (NOAA) from 2018 to 2019 global sea level rise (SLR) was 6.1 mm. Over the last 100 years, the average SLR has been 1.8mm (Chen et al., 2012). SLR is projected to increase up to 5 m by 2100 as a result of melting glaciers, ice sheets, and ice caps (Dasgupta et al., 2009). While this melting does not usually occur in tropical regions, the implications of SLR are experienced throughout Southeast Asia. SLR is associated with several environmental issues that are prevalent in Myanmar including coastal erosion, flooding, changes in groundwater quality and subsequent decreases in agricultural production (Chen et al., 2012).

For each meter of SLR, Myanmar is projected to lose 0.85% of its rice cropland (Chen et al., 2012).If long term estimations are correct, a 5-meter increase in sea level could result in a loss of over 6.5% of Myanmar's available rice cropland and up to a 10% decline in rice production (Chen et al., 2012). Under these circumstances the price of rice could jump by as much as 22%, which would have a massive impact on food security regionally in Myanmar, and worldwide (Chen et al., 2012). According to the World Bank, Myanmar has a poverty-rate of 37% (The World Bank, 2021). Moreover, people in Myanmar spend 60% of their income on food (The World Bank, 2021). meaning the price of a staple food like rice rising could have disastrous implications for the average Burmese person.

1.4.3 Precipitation and flooding

Rice is predominantly grown in monsoon season in Myanmar, which lasts from May to October. Rice paddies require extremely large amounts of water and are often grown in rain-fed river deltas.

Most years during monsoon season these rain-fed deltas produce as much rice as the dry-zones, mountainous and coastal regions combined (Myint, 2018). Although monsoon rainfall is intergral to plentiful rice production, excess precipitation and flooding related to tropical storms can also be detrimental. For example, floods tied to monsson rainfall during a La NiÃśa episode in 2003 led toa 14% decline inrice exports the following year (Brakenridge et al., 2017). While rice cannot be grown without adequate levels of rainfall, heavy precipitation and extreme weather result in flooding which has proven to be an increasingly prevalent problem for MyanmarâĂŹs rice farmers over the last 50 years.

There are two main types of flooding in Myanmar. The first type has to do with the way in which monsoons and tropical storms hit river deltas hard, triggering river plains to act as runoff generators (Kravtsova et al., 2009). This first type of flood occurs when extra-local runoff from wetter parts of the delta upstream flows downstream onto drier floodplains (Brakenridge et al., 2017). In addition to extra-local precipitation flowing downstream, a second type of flooding occurs when local rainfall concentrates on naturally wetter lowlands, which are often the sites of agricultural fields (Brakenridge et al., 2017). This is known as pluvial flooding. Pluvial flooding is often associated with large-scale rainfall events like monsoons, and other types of extreme weather as they are caused by high levels of precipitation on already saturated soil in floodplains (Brakenridge et al., 2017).

Myanmar's unique geomorphology greatly influences precipitation and flood patterns throughout the country. Most of the rivers in Myanmar are classified as anabranching (Furuichi et al., 2009). This means that the rivers are made up of multiple channels with divided flows as a result of sediment build-up. As sediment accumulates in riverbeds, the flow of rivers is often diverted into smaller channels (Brakenridge et al., 2017). Over the course of a year these small diversions can result in entire segments of rivers to migrate over 100 meters (Brakenridge et al., 2017). Accumulated sediment and diverted channels cause unpredictable river flow which can be a serious flooding hazard.

Throughout the 19th and 20th centuries river embankments and levees were constructed in an effort to protect agricultural land from river channel migration (Hajek and Edmonds, 2014). In addition to levees and embankments, reservoirs and dams also influence flood hazards throughout the country. When dams and reservoirs were being constructed throughout the 20th century, flood control and mitigation were not considered. Most of these dams were designed to have a spillway feature, a system in which excess water can pass through the dam in a controlled manner when the reservoir is full (Brakenridge et al., 2017). This spillway design is extremely susceptible to flash floods when the mechanism fails. In addition to issues with spillway dams, large hydroelectric dams also pose flood hazards (Gupta et al., 2012). These dams trap sediment during floods which in turn creates a sinking delta, a phenomenon that occurs when riverbeds erode due to a lack of delivery of sediment and sink, which increase the risk of flood hazards downstream (Syvitski et al., 2009). Innovations like levees and dams have had moderate levels of success, but when these structures are breached during massive floods, damage is worse than it would be otherwise (Brakenridge et al., 2017). These constructions do not allow for much local flood storage or local flood mitigation, so when these systems fail, they fail miserably.

While geomorphology and human construction certainly play prominent roles in causing flood hazards in Myanmar, factors such as deforestation, mangrove logging, delta subsidence and sea level rise have been identified as other main contributors to what scientists refer to as temporal flood trends (Brakenridge et al., 2017). In the past, flooding has been measured using stationary analysis, a type of flood analysis that relies on the assumption that variables other than time are nonfactors to streamflow (Bayazit, 2015). In the last decade, this type of analysis has come under increasing scrutiny as scientist begin to acknowledge the significance of variables that are influenced by climate change. In Myanmar, deforestation, especially of mangrove forests, has destabilized coast lines and made deltas more susceptible to storm surges (Brakenridge et al., 2017), which are small tsunamis

Figure 1.7: Inundation along the upper Ayeyarwady river in the state of Kachin during normal winter flow (top), monsoon season flow (middle), and unusual floodingâĂŤusually tied to extreme weather–bottom

of seawater that flood coastal land (Seekins, 2009). Subsidence, the rapid sinking of land as a result of human activity, has made both coastal land and deltaic agricultural flood plains more vulnerable to flooding (Brakenridge et al., 2017). Futhermore, rising sea levels have increased the frequency of inundation. All of these factors influence flooding temporally, meaning they cause unprecedented stream-flow inflections and are greatly influenced by climate change.

La Nina, the cold phase of the El Nino-Southern Oscillation (ENSO) cycle, also heavily influences flooding in Myanmar. The wettest conditions and most extreme weather are often associated with La NiÃśa years in Myanmar. In addition to La Nina, other large-scale weather circulations, defined as tropical or global changes in atmospheric and oceanic patterns and weather, affect precipitation and flooding in Myanmar. The Madden-Julian Oscillation (MJO) is a 30-90 day weather pattern associated with anomalous and intense rainfall in Myanmar (Brakenridge et al., 2017). The Indian Ocean Dipole (IOD) has the opposite effect as it causes warm and wet conditions in the Western Indian Ocean but acts as an inhibiter to rainfall during monsoon season in Myanmar (Brakenridge et al., 2017). The Pacific Decadal Oscillation (PDO) is also important to consider as its cold phase induced nearly twice the number of tropical storms as its warm phase does (Brakenridge et al., 2017). Weather patterns and seasonal oscillations greatly influence rainfall, flooding, and agricultural planning. Preparing for and predicating these oscillations and relaying information to farmers throughout Myanmar has proven to be a difficult task. In the case of extreme weather events, lack of communication and infrastructure can prove to be economically detrimental and deadly.

1.5 Cyclone Nargis

Cyclone Nargis was a Category 3 tropical storm that struck Myanmar in May of 2008. Cyclones are low pressure storms that form in the Indian Ocean and are identical to the typhoons that occur in the western Pacific and the hurricanes that occur in the eastern Pacific and Atlantic (Seekins, 2009). The regions that were predominantly affected by Cyclone Nargis were the Ayeyarwady Delta, the Yangon region, and other parts of Southern Myanmar, which are all prominent rice producing regions in the country. Upwards of 140,000 people died, and buildings and croplands were devastated by a 4-meter-high storm surge, which is a temporary rise in sea level as a result of a tropical storm (Seekins, 2009).

Nargis is significant to this chapter not only because it had a monumental effect on rice production, but also because it is a prime example of the failures of Myanmar's military government to protect the lives and economic interests of its residents.

When Nargis first hit Myanmar, the storm surge flooded approximately 5,200 square km of coastal and low-lying land, contaminating thousands of rice fields with salt water. An estimated 404, 858 hectares of cropland were inundated by saline water (Seekins, 2009). The storm took over 24 hours to pass through and hit the country on the Western side first, before concentrating over the Southern deltaic region and moving North (Brakenridge et al., 2017). The nature of this storm path was a significant factor in the degree of destructiveness of the storm as the movement triggered a counterclockwise rotation along the shallow southern seabeds of the country, resulting in maximum winds up to 118 km/hour (Brakenridge et al., 2017).

Just like any other major flooding event, population growth, deforestation and human construc-

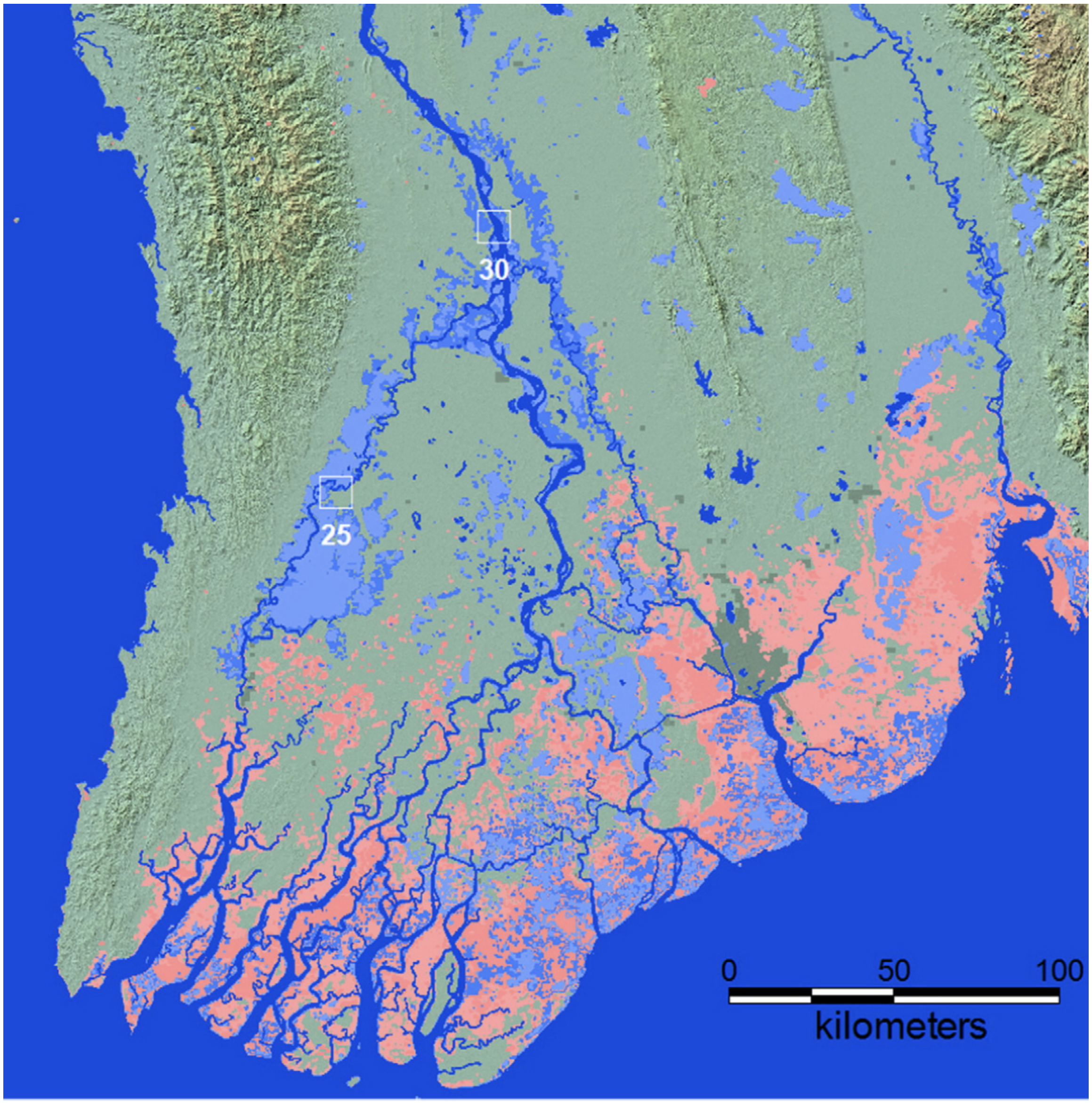


Figure 1.8: Inundation as a result of Nargis (red), compared to typical winter hydrology (dark blue) and average maximum monsoon flood events (medium blue).

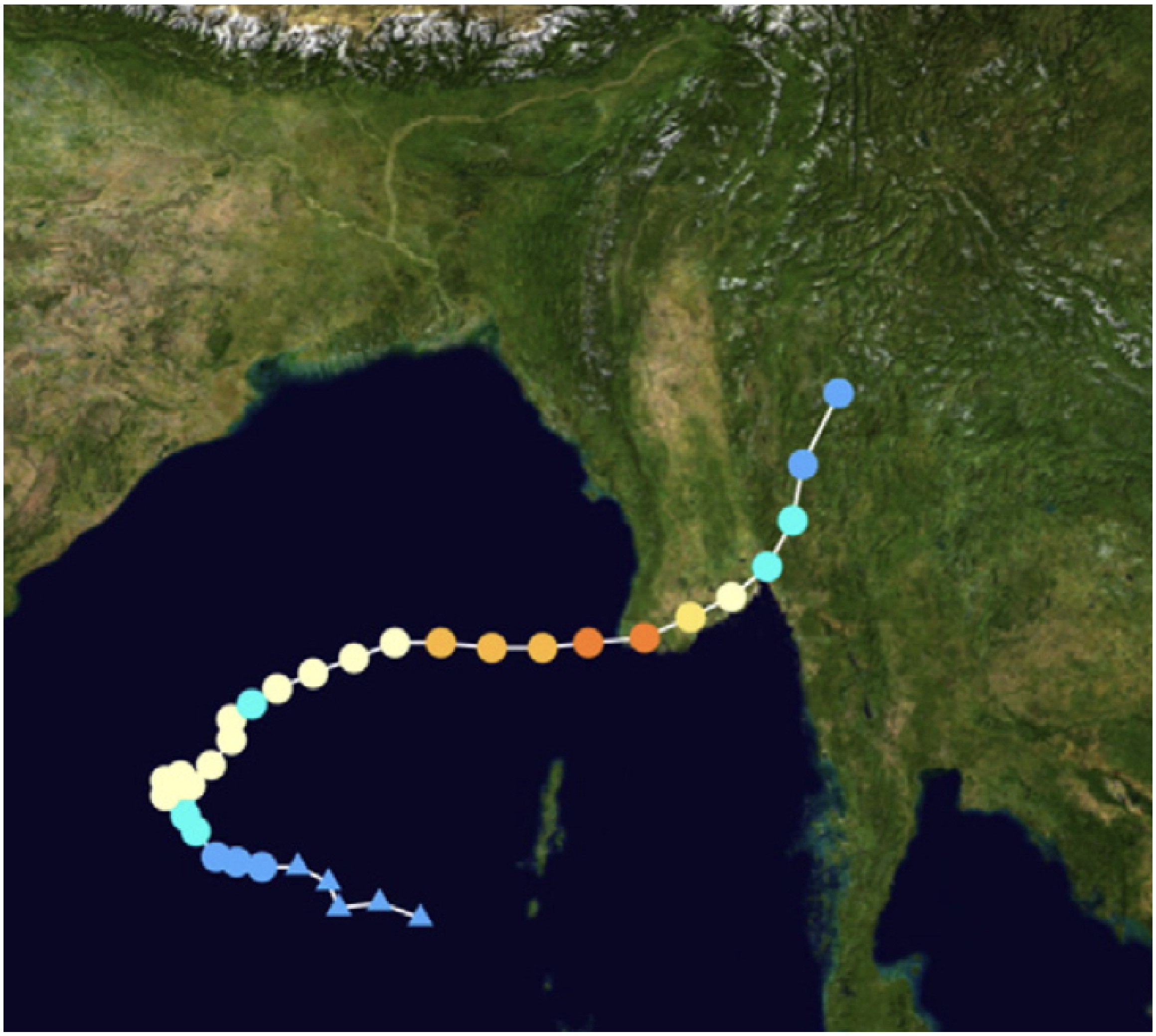


Figure 1.9: Storm path of Cyclone Nargis

tion were identified as long-term causes of the damage inflicted by Cyclone Nargis (Brakenridge et al., 2017). Although these factors are significant, it is important to consider the role of the government of Myanmar in permitting unsustainable dam construction and deforestation to occur, but it is even more important to analyze the country's disaster response, and to hold the military government accountable for their failures to protect Burmese people.

In the days following May 3rd, so much chaos and death ensued that the government of Myanmar stopped counting deaths after the toll reached 138,000 (Brakenridge et al., 2017). Although government officials in Myanmar and weather experts worldwide could predict the areas in the projected path of storm, the government failed to communicate the severity of the storm or highlight evacuation routes to those living in the communities most affected in the coastal south (Brakenridge et al., 2017). Shortly after the cyclone touched down weak infrastructure was quickly overwhelmed. Storm shelters reached capacity and already damaged roads trapped residents in inundated villages (Brakenridge et al., 2017). Many of the deaths tied to Nargis occurred in the weeks following the storm as people in rural areas did not receive proper aid and experienced disease and starvation (Seekins, 2009).

Cyclone Nargis did not impact all the residents of Myanmar equally. Poor agricultural workers and other disenfranchised groups throughout the southern parts of the country bore the brunt of the damage. According to the Post-Nargis Assessment, a project conducted by the Special Association of Southeast Asia Nations (ASEAN), 61% percent of those who died due to Cyclone Nargis and its aftermath were women (Macan-Maker, 2008). Furthermore, thousands of impoverished children were orphaned and had to relocate to cities where they were referred to as âĂIJCyclone Kids.âĂİ (Seekins, 2009). Many of these children became subject to exploitation in new metropolitan environments. Young girls were frequently forced into prostitution and young boys were often recruited into the Tatmadaw, the Burmese armed forces.

In the aftermath of the cyclone, foreign aid and global responses to the disaster were met with hostility and ignorance by Myanmar's military government. When the United Nations called for over 187 million dollars in relief funds, the State Peace and Development Council (SPDC) responded that they would accept foreign aid but wanted absolute control over distributions of supplies and made it extremely difficult for relief organizations to get boots on the ground (Seekins, 2009). As time went on Myanmar's government introduced stricter restrictions on the aid coming into the country. Charity and relief organizations frequently ran into roadblocks where military forces confiscated food and supplies (Seekins, 2009). The SPDC began facilitating propaganda to discourage organizations from interfering with their response to Nargis. The State-run newspaper âĂIJThe New Light of MyanmarâĂİ declared that the residents of Myanmar no longer needed help obtaining food and supplies because they could get vegetables from the fields and fish and frogs from the creeks (the Irrawaddy, 2008).

The corruption and overall inefficiencies that were prevalent in the process of delivering aid remained an issue for different relief efforts and government initiatives throughout the country. The SPDC assigned a government organization called the Union Solidarity and Development Association the task of cleaning up the physical damages to infrastructure in the effected regions. The association quickly devolved into a corrupt and harmful presence in many of the communities they were supposed to rebuild (Seekins, 2009). The task of removing debris and repairing structures was often left to be organized by community initiatives (Seekins, 2009). Over the following weeks the international spotlight on the crisis dwindled and food shortages and corruption continued. Rice was continuing to be exported out of the country even as thousands of residents of Myanmar were starving domestically (Seekins, 2009).

At first glance the occurrence of Cyclone Nargis may seem like a rarity. Large tropical storms usually do not make landing in the Southern regions of Myanmar, especially compared to regions such as Rakhine, which was hit by severe tropical storms 6 times from 1980 to 2000 (Brakenridge et al., 2017). This being said, an event as severe as Nargis is projected to reoccur increasingly frequently as the climate crisis worsens (Brakenridge et al., 2017). Nargis was extremely damaging to agricultural production in Myanmar, and rice farms in particular were devastated by the event. Much of the agricultural infrastructure that was constructed throughout the 1980s in an effort to improve rice yield was severely damaged or destroyed by the storm. Construction projects supported by the World Bank and the Asian Development Bank that implemented drainage systems, polders and sluice gates were made all but irrelevant due to damage (Omori et al., 2020). Many of the embankments that lined man-made canals or polders were busted as a result of flash floods (Omori et al., 2020). Sluice gates, barriers that are used to control river flow were also overrun in the storm (Omori et al., 2020). The very infrastructure that helps sustain high rates of rice production in Myanmar is clearly extremely susceptible to unpredictable weather in this era of climate crisis. Robert Brackenridge, the founder of the Flood Observatory at Dartmouth College, claims that reinforced and sustained flood and sediment management will be necessary to prevent future violent floods in Myanmar (Brakenridge et al., 2017). When considering if this kind of sustained management is possible in Myanmar, one must understand the exploitative role of Myanmar's military government in the history of rice production in Myanmar.

1.6 The Modern History of Rice Production in Myanmar

1.6.1 The 19th Century–The Industrialization of Rice

When the British arrived in Myanmar the rice industry in the country changed forever. Prior to British arrival in 1824, rice was cultivated mostly for home consumption and local trade (Siok-Hwa, 2012). Occasionally rice was exported to nearby regions in Southeast Asia such as Sumatra in Indonesia, but most of the rice was produced for domestic consumption. In the mid 19th century, rice was becoming a desirable good in Europe as it was a cheap staple food and could be used for brewing, bread-making and as a textile (Siok-Hwa, 2012). A large percentage of the rice being imported by European countries was sourced from the Carolinas in the United States (Siok-Hwa, 2012). When the American Civil War broke out in 1861, rice exports from the United States declined rapidly and the European market looked to Southeast Asia to meet the demand for rice paddy (Siok-Hwa, 2012).

In an effort to take advantage of this newfound demand, the British launched largescale land reclamation projects with the goal of converting the forestland and flood plains in southern Myanmar into arable land (Fujita, 2016). Along with land conversion, the British began building new flood control infrastructure mostly in the form of levees. This economic activity in the south was extremely attractive to farmers in Upper Myanmar, and many agricultural workers migrated south where there were ample job opportunities on farms and in busy ports (Siok-Hwa, 2012). In addition to farmers migrating down from northern Myanmar, immigrant workers from India came flooding in throughout the ladder half of the 19th century. This new immigrant work force was composed of laborers looking for jobs in port cities and rice mills as well as wealthier land-owning immigrants known as Chettiars. Chettiars came down to Myanmar primarily to work in banking and moneylending, however the British government remained firmly in control of export and the majority of trade operations (Fujita, 2016). As a staple food, rice has always been extremely culturally significant in Myanmar. The industrialization of rice production in the southern deltas was transformative as it established rice production as the center of economic, political, and social life in the country.

1.6.2 The 20th Century–Rice Production in an Era of Political Transition

As more infrastructure was established and land was cleared for agriculture, rice production steadily increased throughout the first few decades of the 20th century. When the Great Depression struck in the late 1920s rice prices plummeted as many farmers could not pay off their debts and consequently lost land ownership (Fujita, 2016). Revolutionary movements and anti-colonial student-led protests gained traction during these times of economic hardship. Tax protests and hunger strikes led by Buddhist Monks quickly grew to a national insurrection against British rule (Smith, 1991).

In 1937, Great Britain separated Burma from India and established Burma as an individual British colony with its own prime minister and national assembly (Aung-Thwin and Aung-Thwin, 2013). When World War 2 started Burmese leaders used the opportunity to attempt to strike a deal with the British: military support in return for independence (Aung-Thwin and Aung-Thwin, 2013). This agreement never came into fruition and when the Japanese promised Burma independence, the Burmese government formed the Burma Independence Army (BIA) and permitted the Japanese to occupy the region in 1943 (Aung-Thwin and Aung-Thwin, 2013). Although the Japanese declared Burma was a sovereign nation, the Japanese military remained in control of the country's operations and Burmese leaders became increasingly frustrated. Aung San, the figurehead of the Burmese independence movement and the leader of the BIA, shifted the army's allegiance to Great Britain and expelled Japanese forces just two years after permitting the occupation of the country (Aung-Thwin and Aung-Thwin, 2013).

In 1947 the British granted Burma complete independence, but the state of political stability that had defined the country for the previous 20 years continued. Several ethnic-based communist insurgencies ensued in the 14 years between independence and the creation of the Burma Socialist Programme Party (BSPP), which marked the start of the era of military controlled government in the country (Aung-Thwin and Aung-Thwin, 2013). The constant state of political unrest and the amount of damaged infrastructure from the second world war left Myanmar's agricultural economy devastated.

The 1950s were a transformative period for rice production in Myanmar as land use and land tenure were altered drastically. In 1953, the Agricultural Land Act was enacted, and the government seized any plot of agricultural land larger than 50 acres for redistribution (Fujita, 2016). The act also prohibited the sale, rental, mortgage, and transfer of this new nationalized farmland, which essentially cemented the working class as agricultural laborers by preventing them from becoming tenant farmers (Fujita, 2016). This program exacerbated a growing class divide as the government avoided redistributing land to those who had never owned land previously as they feared that these farmers would fail to produce sufficient quantities of paddy (Fujita, 2016).

When the BSPP formally took control in 1962 they introduced an agricultural. This new procurement system was met with a level of resistance by some agricultural communities, but the BSPP responded by seizing the land from resistors and redistributing it to more cooperative farmers (Fujita, 2016). The procurement system was largely ineffective as it caused rice exports to decline, and only by accepting foreign aid was the BSPP able to keep the rice industry afloat throughout the 1970s (Fujita, 2016).

In the 1980s the gap between the procurement prices and market prices for rice steadily increased, culminating in large-scale farmer led protests that were part of the larger Democratic Movement of 1988 (Fujita, 2016). Amidst massive protests the government briefly liberalized the markets which led to a monumental surge in rice prices (Fujita, 2016). When the State Law and Order Restoration Council (SLORC) squashed revolution attempts and seized control of the country's operations, they swiftly reinstated the procurement system. The liberalization of markets followed by the quick reinstitution of the procurement system hit working class agricultural workers extremely hard.

Although flawed, the procurement system was acting as a safety net of sorts for many farmers. When this safety net was suddenly taken away during the Democratic Movement, rice prices skyrocketed but wages failed to follow suit and actually declined (Fujita, 2016).

Following the Democratic Movement of 1988 farmers lost out in 3 ways. First, the new SLORC, which later became the SPDC, decided they would no longer subsidize fertilizers, pesticides, and oil in the agricultural sector. Farmers now had to pay international prices for said goods without benefitting from the international demand for rice. Second, they continued to lose money as the procurement price remained well below the domestic market prices. Lastly, privatized rice export remained prohibited resulting in lost profits as international prices were substantially higher than domestic ones. The 1990s were not much better for rice farmers. Although, things appeared to get off to a better start when rice exports increased due to the introduction of the Summer Paddy Program (SPP) of 1992 which introduced new growing technologies such as double cropping in order to produce more paddy in the summer season. Many farmers preferred to supplement their rice crop income by growing beans and legumes in the summer and were reluctant to adopt the technologies and guidelines proposed by the SPP. Although the SPP increased rice production, it also contributed to the growing distrust and disapproval of government agricultural projects and programs that is still present in Myanmar today.

The exploitative nature of the procurement system continued through the late 1990s as farmers were prohibited from making any private deals before meeting the state quota (Fujita, 2016). Farmer's fatigue of the procurement system became evident as the quality of rice declined severely. Myanmar's export prices for rice were 70% of what Thailand was fetching, and 25% of Myanmar's rice was classified as damaged compared to Thailand's 5% (Fujita, 2016). The quality of rice was so poor that many state employees would immediately sell the product as animal feed instead of relaying the goods to domestic and global markets (Fujita, 2016).

1.6.3 The 21st Century-The Slow Process of Liberalization

In 2003 the SPDC once again briefly suspended the procurement system and tested the waters by allowing the private export of rice on the condition that the state kept half of the profits of these private sales (Fujita, 2016). Just like in 1988, rice prices increased rapidly, and the procurement system was reinstated. In 2007 the government began allowing private rice export using a quota system that collected a 10% export tax, a system that was much more successful than the 2003 attempt (Fujita, 2016). Still the procurement system remained problematic as instead of acting as means of food security following the onset of Cyclone Nargis in 2008, Myanmar's government continued to export rice despite a massive food shortage (Fujita, 2016).. In 2011, as a part of a wave of democratic reforms that were backed by the military government, the rice market was finally liberalized entirely. This decision was likely made due to narrow price differentials between export and domestic prices, which prevented rice prices from spiking at the time of liberalization (Fujita, 2016).

In addition to liberalizing agricultural markets, the government took steps to both increase rice production and create better food security. The Vacant, Fallow, and Virgin Lands Act of 2012 highlighted unused land that was suitable for agriculture. At this time Myanmar had the most undeveloped land of any country in Southeast Asia, and the hope was that some of this land could be converted to farmland in order to increase economic productivity, even if that meant sacrificing conservation efforts (Fujita, 2016). The government also created the National Buffer Stock Committee which launched township-level committees that purchased rice as buffer stock, which helped to stabilize rice prices (Fujita, 2016). Throughout the 2010s the increasingly democratic government took steps to provide more stability to the agricultural workers who are the backbone of the economy. Although it is too early to tell the long-term effect that the 2021 military coupe will have on the rice industry, constant political turmoil and violence is damaging to the agricultural economy and the society that has developed alongside the rice industry.

1.7 Conclusion

Being the staple good in Myanmar, rice is of extreme cultural significance. The crop is eaten at practically every meal and more than half of the jobs in the country have something to do with the product. As detailed in the historical section, rice influenced people to immigrate. The crop created cultural and social hubs and is extremely tied to class. Rice is a wage-good, meaning its price has strong implications on the economy, wages, and the well-being of Burmese people (Fujita, 2016).

In his book "The Myanmar Economy" Koichi Fujita utilizes the term "rice trauma." Rice trauma as a concept refers to the trauma that is tied to the rice industry, trauma experienced by Burmese citizens and by members of the Myanmar military government. Rice existing as a wage-crop in Myanmar links the good not just to wages, but also to movements. Protests in the 1930s, the 1988 uprising, and social unrest that followed Cyclone Nargis were all explicitly tied to rising rice prices. Burmese citizens experience rice trauma when prices rise and the economy becomes increasingly unstable, and the government experiences rice trauma because they associate changes in the rice industry as having potential to start political movements. This idea of rice trauma is a prime example of the political economy and ecology of rice. Throughout the history of the country, rice has acted as a political vessel.

As the onset of the climate crisis continues over the next century, scientists have stated that agriculture needs to change. Evidence shows that crops will need to become more resilient and agricultural practices must strive to be increasingly sustainable as the world begins to deal with extreme weather and increased temperatures. While alterations to established agricultural processes may be relatively easily to implement in countries with extensive resources and stable economies, a developing Southeast Asian country such as Myanmar will struggle to build upon weak infrastructure and will face strong opposition in the form of corruption and political instability.

The 2021 coup is evidence that while it is easy to highlight the agricultural technologies and reform that is needed, Myanmar's complicated political history and continued political instability will hinder its ability to adapt in the face of the climate crisis. However, if a democratic government is successfully established in Myanmar, other Southeast Asian countries may look to Myanmar to lead the way as the country can set a precedent by sustainably developing the large intact landscapes that show economic and ecological promise throughout the country.

Chapter 2

Tropical Cyclones in the Philippines

Ian Horsburgh

[MLH: maybe add to the chapter name: and the Carnot Engine and Climate Change... yes, too long, but you have some cool stuff at the end that needs to be made more visible!]

2.1 Tropical Cyclones in the Philippines

2.1.1 A Storm is Coming

The day is Wednesday, November 6th 2013. In the Visayan Islands, the central islands of the Philippine a[MLH: A?]rchipelago, the people prepare for a storm. Just days earlier, after a south Asian weather station had begun monitoring a low pressure area east of Micronesia, the storm had been named Haiyan, and been declared a category 5 super typhoon. While Hayian is expected to be the most powerful tropical cyclone ever to hit land, devastating tropical cyclones are not new to the Philippines. One rural Fillipino agricultural worker, Angeles Grefiel, speaks of how past storms have wiped out his crops, leaving him with no money to provide his children with a healthy diet. "We have generations of children that have grown up without having proper access to the right types of food," says Grefiel, a sentiment echoed by Evangeline Aloha, a resident of Leyte Province in the central Philippines, who worries she will have no income if the harvest is wiped out by the storm. As certain cash crops are easily wiped out by heavy rain, many farmworkers like Evangeline and Angeles are "so vulnerable to disasters that when one strikes, it takes them further and further into that cycle of poverty," says a local social worker, also in Leyte Province. To see why certain crops are planted and how they make the country so much more vulnerable to tropical cyclones, we must take a look back on the history of agriculture in the Philippines. [MLH: great intro!]

2.1.2 Agriculture and Cyclone Vulnerability?

Rural Filipino farmers are vulnerable to tropical storms in part due to their integration into worldwide markets. In particular, famine is often a product of the conditions surrounding access to food. "Famine must be seen not as an absolute scarcity of food in particular regions, but rather as a loss of oneâĂŹs[MLH: fix apostrophe] entitlements[MLH: does the word have a different meaning than to US uses?] to food and/or the means of subsistence," writes Warren (2018). As for Fillipino farmers, this loss of entitlement goes back to the colonial era. Throughout history, rice has been a staple crop in the Philippines. Due to the favorable and temperate climate, Fillipino farmers were able to harvest rice twice a year, while simultaneously planting root crops such as sweet potato. When typhoons "created severe food shortages for those who grew rice, these root crops became...the âĂŸ[MLH: look up how to do quotes and apostroshe's in LaTeX, you have it right in some sections..., the problem for me when I cut and paste in to Rstudio]refuge of the poorâĂŹ"(Warren, 2018). However, in the nineteenth century, this dynamic began to change. Spanish colonization of the Philippines began in the 1500[MLH: âĂŹ]s, although major agricultural change, especially as it relates to globalization and integration into market economies started in the early 19th century. This began with "the Spanish practice of rewarding the Catholic orders for their conversion efforts with land," which "turned the church into the largest landlord in the islands"(Ventura, 2016). Spanish catholic landlords then divided up their land, and under this system, "Inquilinos (tenant landlords) paid annual rents for lands they then subdivided among sharecroppers, who often further subdivided their portions, which would be worked by families living in a central town near the fields"(Ventura, 2016).[MLH: any figure could break up the text here] This system was a major step towards the integration of Filipino farming into the global economy, due to the fact that "as estates commercialized, they increasingly shared management with Chinese-Philippine mestizo businessmen," who had access to British capital (Ventura, 2016). When America resumed colonial control following their defeat of Spain in the Spanish-American war in 1898, there were a number of changes to this system, but integration into global markets continued. At the beginning of the United StatesâĂŹ rule,[MLH: super interesting!] the new leadership feigned effort to give farmers independent ownership over their land, but just two years later abandoned this effort, apocryphally citing lack of interest in this initiative by the peasants (Ventura, 2016). Former president William Howard t[MLH: T]aft, the civilian governor of the Philippines from 1901 to 1904, then changed direction entirely, saying that "easing the homestead lawâĂŹs limitations on corporate ownership to 2,500 acres[MLH: ... is better spacing]...was a much better path to development." Following this reversion to a similar corporate control as implemented by Spain, "prevailing inequalities of landholding and rural wealth during the Spanish period multiplied under US rule." Ventura (2016) summarizes the issue, saying that the United StatesâĂŹ "failure to establish independent homesteads was akin to other alleged shortcomings in hygiene and sanitation, education, and banking, thus justifying the US presence in the islands," and consequently "ownership for large scale plantation agriculture." US Civil Service Advisor Roy Franklin Barton talks of the American reforms in the agricultural region of Ifugao, describing how the new "availability of wage labor jobs" makes way for "the introduction of money into the province replacing the old rice currency," and thus "the integration of a market economy" (Klock, 1995). Thus, Spanish and American policies in the Philippines transitioned the country from local to large scale plantation agriculture.[MLH: add a line if you want a new paragraph] This incorporation into large scale plantation agriculture and world trade had large impacts on the vulnerability of the area to natural disasters, such as typhoons "There is persuasive evidence that peasants and farm laborers became dramatically more pregnable to natural disasters after 1850 as their local economies were violently incorporated into the world market," writes Davis (2002). "The vulnerability of tropical agriculturalists to extreme climate events after 1870 was magnified by simultaneous restructurings of household and village linkages to regional production systems." In refuting claims that farmers chose to adopt to this new age agriculture because it provided a better life, Davis argues that âĂIJRecent scholarship confirms that it was subsistence adversity (high taxes, chronic indebtedness, inadequate acreage, loss of subsidiary employment opportunities, enclosure of common resources, dissolution of patrimonial obligations, and so on), not entrepreneurial opportunity, that typically promoted the turn to cash-crop cultivation.âĂİ[MLH: great quote, need page number] This cash crop cultivation became the primary type of farming in the Philippines by the mid 19th century, and even farmers who still owned land were increasingly "encouraged to plant cash crops of abaca, copra, tobacco and sugar, and were often forced to sell rice below market prices"(Warren, 2018). By the 20th century,much of the rice still produced by the Philippines was exported to China, while poor Filipinos lived "almost exclusively on imported rice, tubers and corn" (Warren, 2018). Thus, rather than the pre-colonial model of growing rice and root crops, a model that was fairly robust in the face of typhoons, farmers in the colonial Philippines who were encouraged to grow cash crops and buy imported rice, as well as those who now worked plantations for a wage, were left with no money and thus no food when cash crops were wiped out by typhoons. As many cash crops rely on long fertile growing seasons for harvest, and thus were much more easily disrupted by storms, "subsistence farmers, who increasingly chose to cultivate cash crops, counting on a better standard of living,[MLH: can you make a diagram of this? maybe not, just think about it] often found they had no visible means of sustaining themselves, because of the âĂŸeconomic predicamentâĂŹ triggered by typhoons," writes Warren (2018), again. Thus, in the shift from a diversified to monocrop economy, agricultural, and thus economic disaster became "a fact of life" In sum, as colonial powers such as the United States and Spain implemented policy that shifted Filippino agriculture toward cash crop cultivation within worldwide markets, and away from a local multicrop system, the country became more vulnerable to typhoons.[MLH: really interesting history!]

[MLH: I think this might be a good place to talk about how cyclone work...]

2.1.3 Ready or Not

[MLH: not very descriptive as a subsection name...] As the supertyphoon Hayian approached the Philippine islands, the government scrambled to alert those in danger, but to various degrees of success. While some in danger, like Retche Ycoy, did not receive any warning–"We didnâĂŹt expect this was going to happen. We were just sitting around in our house and the wind suddenly started"–others, like 62 year old taxi cab driver Eduardo did not realize what the warnings meant. Recalling the situation, he said, "What I understood was that there would be a strong wind. We never understood what a storm surge meant."[MLH: what's the source of these quotes?] Others still, like Celina Camposano of Leyte were told to evacuate. While these responses vary from having heard no warning whatsoever to being evacuated and sent to higher ground, they all share one sentiment: their past experiences with tropical storms did not prepare them for what was about to come. [MLH: paragraph] From educating and warning those in danger to helping those affected find food and shelter, the federal Philippine response to tropical cyclones like Haiyan has many obligations. In this section, we will investigate what this response entails, what areas it is successful in, and how it can improve.[MLH: seems odd that this is present tense, but I can think of ways that this work in the intro, but not sure about now...] While âĂŸdisaster mitigationâĂŹ can mean many things, we [MLH: ~~will~~] separate it into post disaster recovery, and pre-disaster preparation.

[MLH: to reference figure...Figure 2.1, bute needs a better reference name!]

2.1.4 Philippine Disaster Mitigation

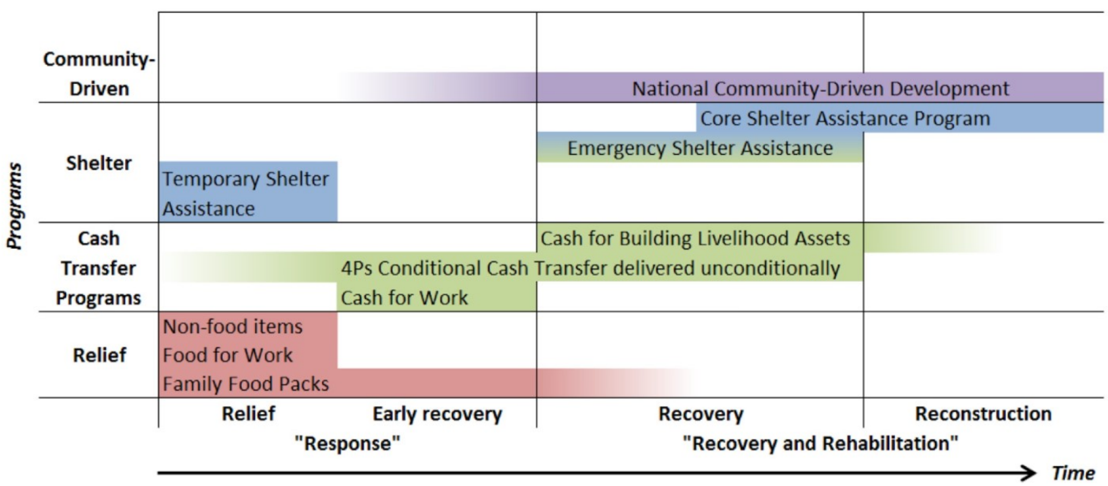
The Philippines has a number of programs aimed at disaster relief, as seen in figure 10.2.[MLH: add reference to auto number]Typhoon Haiyan, locally know as Typhoon Yolanda, was disasterous. With 195 mph 1-minute sustained wind speeds, Yolanda[MLH: confusing to have two names] was the most powerful storm ever to make landfall at the time. With 6300 people dead, and a million houses destroyed or damaged, the Philippine government had much work to do to provide relief for those that survived the devastating storm. Immediately after the storm, the Department of Social Welfare and Development (DSWD) provided shelter assistance to many displaced households. For nearly 60,000 household, this came in the form of emergency shelter kits. Although the kits were

Figure 2.1: A Ship is washed ashore in Tacloban City [MLH: let use a more descriptive label remember there are 16 chapters! also need to be one word or hyponated word.]

helpful in providing emergency shelter, the number of families that received the emergency shelter assistance was limited due to an insufficient supply of kits delivered. (Bowen, 2015). In addition to these kits, DSWD helped to coordinate the delivery of 136,267 roofing solutions to help with roofs that had been blown off, like PapooseâĂŹs. Concurrently, other families were sent to shelters or bunkhouses, and by the 5th month of the response, many of the families who were originally living in emergency shelter kit housing were transferred to more substantial bunkhouses as well. However, this relief housing was not sufficient for all. Another program implemented by DSWD was Food for Work.

In the DSWDâĂŹs food for work program, “Beneficiaries were given food packs in exchange for the provision of their labor to assist in the repacking and distribution of relief goods” (Bowen, 2015). This both helped to expedite the processing and distribution of food packs, and employ/guarantee food for those who lost their job as a result of the tropical cyclone. As the needs of the workers moved beyond immediate shelter and survival, this Food for Work program was replaced with Cash for Work. In the Cash for Work (CFW) program, which continued long into the relief effort, jobs included “loading/unloading of goods, repacking of relief goods, food preparation, sorting and inventory of damaged property, clearing of debris, coastal clean-up, and canal dredging, among other things” (Bowen, 2015). By 2014, 15,188 people were participating in CFW, which “helped to provide much needed additional assistance to DSWD relief programs on the ground, while providing beneficiaries with cash based assistance”(Bowen, 2015). Programs like Cash for Work, however, would not have been possible without existing cash transfer infrastructure. The DWWD, with the help of humanitarian organizations, capitalized on strong pre-existing social welfare programs, especially cash transfer infrastructure, to provide monetary relief in the wake of Hayian. In total, “Four agencies alone in the inter-agency response distributed around US$34 million, benefitting 1.4 million disaster-affected people”(Bowen, 2015). This money was distributed in various ways, with around 70[MLH: %] percent of cash transfers being conditional (Cash for work, etc), and 23 percent being unconditional. Although this system works well, the Phillippine government should learn from and refine this cash distribution process for future disasters, as a number of issues in “coordination leading to coverage gaps and duplication” of funds were reported during the Hayian relief period(Bowen, 2015).[MLH: maybe define the problem then tell how to solve?] In addition to government aid, local relief and community driven development was key to post-Haiyan recovery.[MLH: we could create a table of activities and their evaluation and recommended changes, make be better than to have all in text?] Community driven development refers primarily to the subsection of the DSWD

Figure 1: The primary response, recovery and reconstruction programs of DSWD in the case of Typhoon Yolanda



Note: "Relief, early recovery, recovery and reconstruction" refer the typical international conception of the post-disaster phases over time. "Response" and "recovery and rehabilitation" represent the GoP conception of these phases. They align as illustrated on the figure's x axis

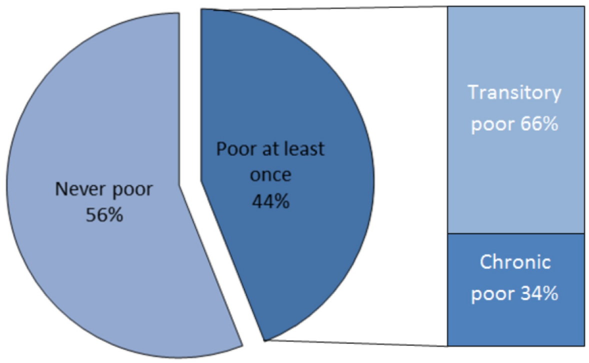
Figure 2.2: DSWD Relief Programs

called the National Community Driven Development (NCDD) program that operates primarily on local levels and was established in 2002 to help alleviate rural poverty, especially surrounding disasters. In addition to implementing general infrastructure, the NCDD is well poised for disaster relief due to its geographical breadth and "has a well established network of community facilitators and community volunteers on the ground"(Bowen, 2015). Following Yolanda, the NCDD played a large part "in the rebuilding/rehabilitation process" of affected communities by taking on projects such as rebuilding roads, paths/trails, schools, flood/drainage control structures, water systems, and health stations. Thus, "The Yolanda experience has also demonstrated the important role that community driven development programs can play in the recovery of poor and vulnerable people from disasters"(Bowen, 2015). Finally, the Core Shelter Assistance Program helped those affected by the storm find housing. In an effort to build more secure and resilient housing, the DSWD implemented the Core Shelter Assistance Program (CSAP), which aims to establish permanent safe housing for the rural poor. Following emergency housing after a storm, the CSAP builds "a standardized two-room structure that is built to withstand 220 kmph wind-speeds"(Bowen, 2015). As a testament to the durability of these shelters, a local Social Welfare and Development officer stated that "The core shelter units built through the CSAP of DSWD are still standing even after the mighty force of Typhoon Yolanda...all 80 units built in 1991, 2000 and 2010 in Barangays Cansuso, San Marcelino, San Sebastian, and San Guillermo remain standing"(Bowen, 2015).[MLH: I don't know anything about construction, but that seems impressive! Is it?] Thus, this program provides robust housing that not only serves as relief for typhoon victims, but actually serves to mitigate future damage caused by natural disasters. Overall, the Philippine government has established a fairly robust system for addressing typhoon relief, combining immediate food and shelter relief with one of the best social protection programs in the region, which helps many residents with both immediate survival and monetary subsistence. However, despite these systems to address relief, many residents still live close to the poverty line. As seen in the figure 10.3[MLH: autoref using a refernce to a label], 44% of Philippine residents experience poverty at least once, and of those that do, 2 out of 3 are in and out of poverty, often triggered by typhoons like Yolanda. While the systems described above do well to provide relief following a tropical storm, thus making the poverty triggered by the storm only transitory, other adaptation and mitigation measures could help reduce the need for such extensive post disaster support as well as decrease the number of deaths immediately caused by typhoons. While some measures described above, such as robust housing, function in this way, there are a number of other measures that can be taken to reduce the effects of tropical cyclones.

[MLH: check this out..., is there something like this for the philippines? https://cran.r-project.org/web/packages/hurricaneexposure/vignettes/hurricaneexposure.html, if not it begs the question, great educational tool, perhaps]

[MLH: new section/subsection?] Disaster mitigation takes many forms, from long term prevention to recovery. As we have previously discussed recovery and post-disaster mitigation, which the Philippines has demonstrated great competency in, we will now talk about prevention, a sector which the south asian archipelago will need to invest in to mitigate damage caused by future storms. The first form this investment could take is protecting natural land features.[MLH: is there a science to disaster relief that we could add?] While man made structures such as walls and barriers offer some protection and psychological reassurance, they are not an ideal long term solution to cyclone mitigation (King et al., 2010). This stems from a few factors, the first of which being their high maintenance costs, which leads to neglect, and thus causes a dangerous scenario of false security, as was observed in hurricane Katrina in New Orleans in 2005. Another downside of man made structures is that if they are breached, they often keep water in, creating a ponding effect that "severely constrains response and recovery"(King et al., 2010). Instead of man made infrastructure, many researchers emphasize the importance of retaining natural land features. Natural features

Figure 3: Poverty Status 2003, 2006, and 2009



Source: World Bank (2014), Country Partnership Strategy for the Republic of the Philippines for the Period FY2015-2018, p 4

Figure 2.3: [MLH: change the reference label to something more descriptive and then we can use a reference in the text.]

such as coral reefs, mangroves, and dune ridges "are extremely effective in controlling storm surge flooding," writes King et al. (2010).[MLH: seems like this could / should be a new section to focus on 'best practices'] While coral reels are able to absorb "some of the power of tropical cyclone wind-generated waves and surges" before they hit land, mangroves are crucial to providing relief as they are extremely resilient to tropical storms, and often provide shelter and safety to people and boats around them (Williams et al., 2007). While only 20% of the once 500,000 mangroves in the Philippines remained by the early 1990âĂŹs, local and national authorities observed this effect of mangrove protection from tropical storms, and have planted 600,000 mangroves since 1996. In addition to typhoon protection, this has had other benefits such as improved fishing and ecotourism (Williams et al., 2007). Williams et al. (2007) notes, however, that although Philippine legislature in planting mangroves for cyclone protection could be considered a success story, enforcement is "often wanting," and continuous efforts must be made to maintain the progress the country has made in this respect. The final natural feature that has been observed to help prevent typhoon damage is coastal dunes, behind which "lagoonal wetlands absorb immundation"(King et al., 2010). Unfortunately, these are in great danger, as "coastal zones have been cleared, settled, and built over"(King et al., 2010). Thus land use planning and legislature are crucial to maintaining, or many cases such as that of mangroves, rebuilding natural infrastructure to mitigate typhoon damage. In addition to infrastructure, education is imperative to disaster mitigation. Mitigation measures have little to no impact "if the people do not know the hazard risk" or "are unaware of evacuation routes, sheltering strategies, and appropriate response to warnings," as demonstrated by Eduardo and Maria (King et al., 2010). "Many people who may have been through a Category 1 or 2 cyclone have no awareness from that experience of what a Category 3 or 4 will do," writes King et al. (2010), again. As the pre-existing idea of what the storm will look like may contradict official reports, vulnerable populations must be educated on what different categories of storms mean, and what responses are appropriate for the divergent levels. Once these warnings are understood, a robust warning system is extremely helpful in preventing injuries and casualties due to storms. In sum, the Philippine government has created a robust post-disaster relief system that encompasses housing, food, and work. However, to mitigate the damage caused by future storms, the country must invest in protecting natural features such as mangroves, coral reefs, and coastal dunes, as well as strengthen education programs on tropical cyclones.

[MLH: Okay, I like this, but let's integrate into the text..., perhaps this could be inerted into the areas where you talk about colonilizatoin and talk about long term land use affecting resilience of mangroves?? Maybe too much to force, but it might break up with history with some ecology in a nice way and demonstrate some vulneratility linked to colonial land use changes – if that actually happened???]

2.1.5 A Changing Game

[MLH: perhaps a better heading to be more transparent] Compounding issues of lack of education[MLH: lack of education is a strnge beast, some can 'see' this as a lack of interest by residents, lack of motivation, others will blame gov't. I wonder if we can make sure the reader gets your intention here] on tropical storms is the fact that the nature of these storms is changing. Some residents, such as Maria Flora Orbong of Tacloban City understood what the storm surge meant, yet was still underprepared for storms of HaiyanâĂŹs magnitude, remarking that "We knew that a strong typhoon was coming but we didnâĂŹt really expect the water [levels] to rise that high âĂę[MLH: ...] our neighbors evacuated but we thought we were safe. We were in the middle, surrounded [by cement houses]." Less than an hour after the storm hit the Island, however, things were far from expected. "The waves rose to six or eight metres (20 to 26 feet)...many people started to escape but the ships washed up and many people died," recalls Orbong. Celina Camposano of Leyte echoes the novelty of this storm, saying "WeâĂŹve never experienced something like this before âĂę [MLH: ...]weâĂŹve never had to evacuate before." While some of this gap between expectations and reality is due to lack of education on cyclone threat, another reason locals were unprepared for what typhoon brought was that the nature of these types of storms are changing. To understand this change, we must look at how tropical cyclones work and how they are affected by climate change.

2.1.6 Tropical Cyclones and Climate Change

Tropical cyclones, referred to as typhoons when taking place over the Pacific Ocean, occur in southeast Asia primarily in the late summer and fall. Distinct from the monsoon season, which describes the prevailing wind that causes a predictable rainy season in the summer months, typhoons are isolated and severe events, sometimes accounting for more precipitation than the entire monsoon season brings[MLH: interesting!]. Typhoons typically form in warm equatorial ocean waters, as the warm air near the surface rises, leaving an area of lower pressure below. Soon, a cycle forms, with surrounding air moving into the lower pressure region before heating up and rising itself. Once the risen air cools off, it forms clouds, which are then fed into the cycle, as seen in figure [MLH: 10.4] Other characteristics often accompany this air and cloud flow, such as torrential rains and a storm surge which can elevate the sea surface 20 feet and cause widespread flooding.

To represent how these tropical cyclones operate, climate scientists often employ the Carnot Engine model, a theoretical thermodynamic cycle that provides an upper limit on how powerful a storm can be (Emanuel, 1987). The model depicts fluid[MLH: air is modelled as a fluid, but I wonder if readers will get that? and why?] that performs work (a measure of energy transfer that occurs when an object is moved) on its surroundings while undergoing four stages, the fourth of which returns to the first, making it cyclic.[MLH: is there a figure that shows this? Are there some equations that might demonstrate how the model works? I wonder if we can create a little simulation? `https://www.researchgate.net/figure/Carnot-cycle-Figure-5-Structure-of-a-hurricane-Air-is-cooled-through-co`

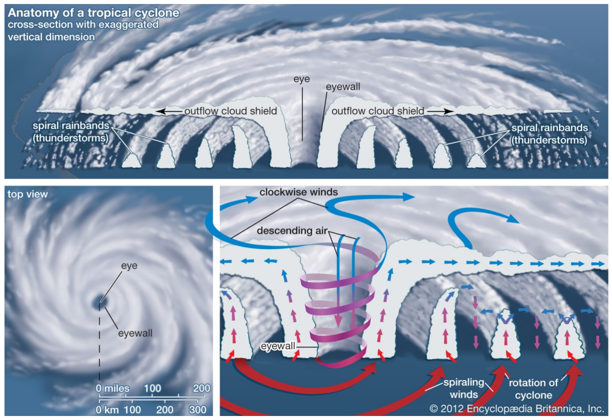


Figure 2.4

fig1_323693275] In the case of a cyclone, this fluid takes the form of a mixture of dry air, water vapor, and suspended condensed water, all of which are in thermal equilibrium (the same temperature). However, as the ocean and the atmosphere are in thermal disequilibrium (not the same temperature), the ocean loses heat to the atmosphere by evaporation of water, which has a large heat of vaporization (Emanuel, 2006).[MLH: this is super interesting and deserves more space if you can figure it out!] The carnot cycle uses this heat flow as an input to estimate the maximum power output that could be produced if the storm was perfectly efficient. Although this perfect efficiency is impossible, the carnot cycle is useful to give an upper bound on storm power, operating as described in figure 10.5.

[MLH: you should cite earlier chapters...] A quick aside on the greenhouse effect: YouâĂŹve probably heard the term “the greenhouse effect” thrown around, but if you forgot what it is or never learned, hereâĂŹs a brief summary. Of the light radiated by the sun, 30% is reflected by the clouds or surface and the rest is (mostly) absorbed by the earth. The earth then transmits energy up by radiation and convection currents, some of which are absorbed by certain elements in the atmosphere such as water vapor, methane, and carbon dioxide. These molecules are known as greenhouse gasses because they act on the climate as a greenhouse does on a garden, trapping heat in the atmosphere. As a higher concentration of greenhouse gases in the atmosphere leads to a higher temperature, the disequilibrium between the atmospheric temperature and the water increases, thus amplifying the heat flow powering the carnot cycle, which results in a higher upper bound for the intensity of the cyclone(Emanuel, 2006).

All this physics on tropical cyclone modeling provides good intuition for why an increase in greenhouse gas concentration in the atmosphere could lead to more powerful storms, but to really quantify this change, we must look to climate simulations and statistics. To investigate one statistic that is particularly pertinent to quantifying cyclone power and potential destructiveness, we look to meteorologist Kerry EmmaneulâĂŹs work. In his 2005 article Increasing Destructiveness of Tropical Cyclones, Emanuel (2005) noted that “Basic theory,” such as what we have looked at with the carnot cycle, “establishes a quantitative upper bound on hurricane intensity, as measured by maximum surface wind speed.” Observing that “the actual monetary loss in wind storms rises roughly as the cube of the wind speed,” Emmanuel [MLH: would giving a short biography of this person, create

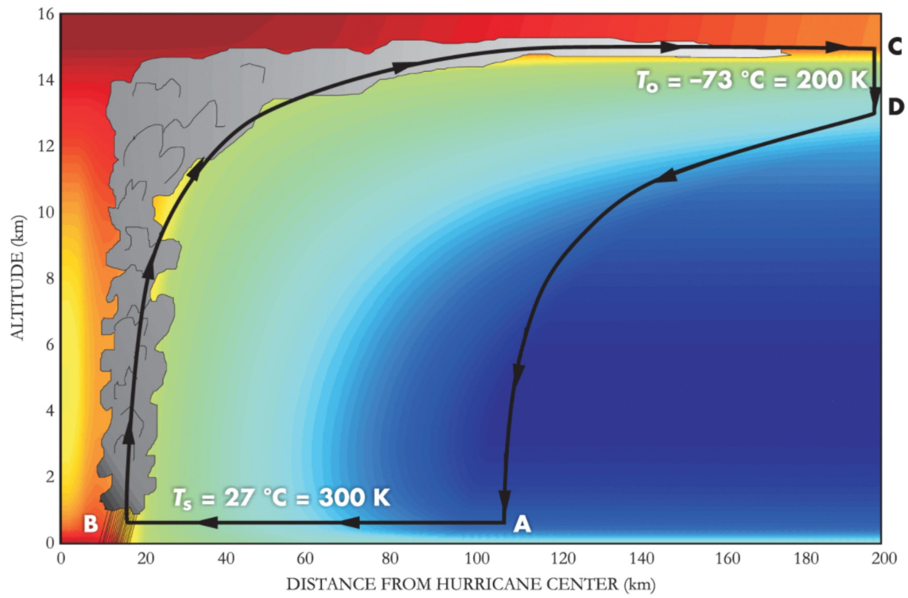


Figure 2.5

more interest in his/her work?]created the Power Dissipation Index, which he defines as:

$$PDI \equiv \int_0^t \mathsf{V_{max}}^3 \, \mathsf{dt}$$

A quick refresher in calculus: the integral represents the area under a curve, so in this case the curve would be a graph of the maximum sustained wind speed of a storm over time (Velocity cubed), and the integral of V3 would be the area under this curve starting at the beginning of the storm t0 = 0, and ending at time t. This is shown by the 0 and t at the bottom and top, respectively, of the integral symbol. [MLH: great!, can we create a simulation and show PDI as it relates to t or v?] A simplification of a previous statistic that was problematic as it input data[MLH: what is the input data needed? I assume that t and V are not enough?] that was seldom recorded, Emanuel (2005) notes that "this [new] index is a better indicator of tropical cyclone threat than storm frequency or intensity alone." Because it does well to estimate the damage of tropical cyclones, only requires one input[MLH: but not measured?], and is easy to evaluate, it is often used to represent tropical storm damage. Using PDI to gauge storm intensity, numerous studies conclude that tropical cyclone intensity will increase under climate change (Zhang et al., 2017), (Emanuel, 2013), (Chen et al., 2021). To apply physics to large scale climatological events, scientists use climate models, which divide up the earth's surface into grid cells, and use complex equations based on fundamental laws of physics, fluid motion, and chemistry to describe how energy and the materials within the grid move through it (NOAA, ????). A visual of this type of model is given in the figure below.

When a model is âĂIJrunâĂİ,[MLH: we can move this the the climate change chapter if you would like and then just summarize the topic as it relates to your chapter, might be less repetitive for the reader and we'll add you to another chapter authorship] scientists set the variables to certain predictable climate conditions, such as greenhouse gas concentration, and solve the equations for those conditions (NOAA, ????). The results are then plugged into the next grid, and so on, repre-

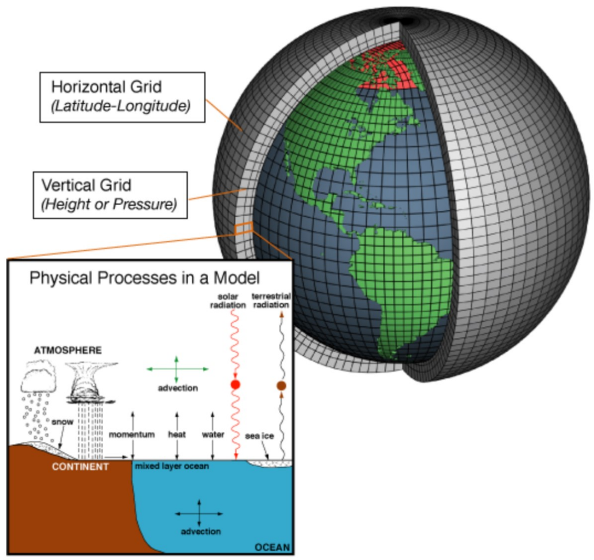


Figure 2.6

senting the passage of time. To test the models, climatologists run the models back in time, ensuring the results are similar to what has actually been observed before simulating future conditions.

[MLH: back to your topic, right?] Applied to tropical cyclones and climate change, these models allow scientists to make conclusions about how greenhouse gasses will affect storms. While the effects of climate change on storm frequency are unclear((Emanuel, 2013), (Chen et al., 2021)), multiple studies have shown an increase in tropical cyclone intensity due to climate change (Zhang et al., 2017), (Emanuel, 2013), (Chen et al., 2021). This finding is in consonance with what the physics of tropical storms predicted (Emanuel, 1987). Presented graphically, this can be seen by an increase in PDI in climate models set for expected greenhouse gas concentrations over the next century (recall that PDI is calculated using wind speed, one of the physical processes modeled in climate models). In sum, tropical cyclones can be modeled with the carnot cycle to predict the maximim power output of the storm. This model predicts that an increase in greenhouse gas concentration will cause storms to become more powerful, a prediction that is backed up by climate modeling.

[MLH: GREAT chapter, I love the physics and discussion of carnot cycle, I think we might back up and teach some thermodynamics as another "interuption" into the history of the phillipines, I have some ideas of you want to think about it]

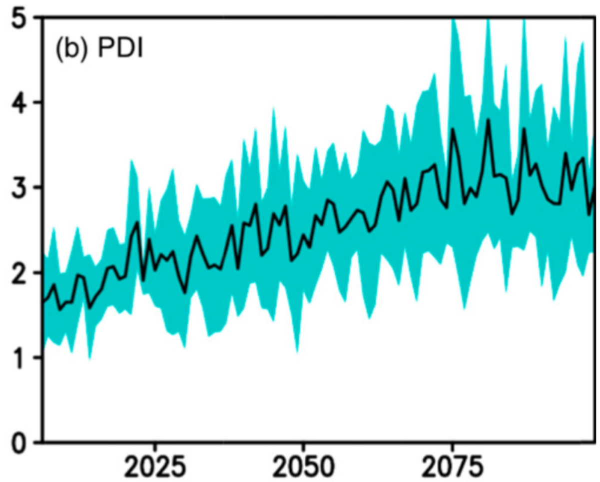


Figure 2.7

Chapter 3

Climate Infrastructure in Vietnam

3.1 Introductory

How climate change will impact Vietnam

Flooding (especially coastal urban areas)

Sea Level Rise

Land Erosion

Health outcomes

Current Adaptation Plans

Strengthen existing barriers and infrastructure

Adapt cities expecting sea level rise

Withdraw from the coastlines in areas that are well below sea level

What's Needed for the Future

Stronger healthcare system

Support for farmers and agricultural workers

Support for rural population near Mekong and Red river deltas

3.2 Conclusion

Implications for other places in the region

Chapter 4

Coral Reefs, Ecosystem Services, and Indigenous Peoples

David Chengwen Gorman

[MLH: added LaTeXfunction for chapter author...]

4.1 Coral Reef Ecosystem Functioning and Interactions

4.1.1 Coral Reefs: An Introduction

In November 2018, North Sentinel Island, an island in the Bay of Bengal smaller than 60 square kilometers, drew international attention after its indigenous inhabitants killed an American missionary.[MLH: might be a good place for a map?] The Sentinelese, one of the last uncontacted people groups in the world, have occupied North Sentinel island for the last 60,000 years.[MLH: cool!] Surrounded by shallow, razor-sharp reefs, the Sentinelese have managed to remain isolated from the rapid development of neighboring Southeast Asian countries and still practice traditional customs and ways of life (Smith, 2018).

This hunter-gatherer tribe is just one of the thousands of Southeast Asian communities that rely on coral reefs for both protection and sustenance. While most do not practice the traditional hunter-gatherer harvesting practices of the Sentinelese, coral reefs remain fundamental to the lives of millions across Southeast Asia.[MLH: great intro, hope you come back to these folks. . . , good to circle back in general] Unfortunately, coral reefs face significant threats and at the current rate of degradation, reef survival is unlikely. The declining health, in terms of biodiversity, biomass, and fitness, of coral reefs impacts not only the overall condition of the global environment, but negatively affects the majority of the Southeast Asian population.[MLH: including the Sentinelese??? if so, how?]

The coral reefs have become vital components of many Southeast Asian, coastal communities and indigenous groups alike. This fragile, colorful marine ecosystem boasts high levels of both biodiversity and biomass, which are vital to both reef survival as well as the millions worldwide dependent on reefs for sustainably and economic prosperity. These life sustaining ecosystems are akin to the rainforests of the sea. There are nearly 100,000 square-kilometers of coral reefs in Southeast Asia supporting 600-800 different coral species.[MLH: this doesn't sound like much. . .] Healthy coral reef ecosystems provide various anthropological benefits, or ecosystem services, to people of all socioeconomic backgrounds. They provide food to over a billion people annually[MLH: via habitat for nursery gounds?], are a major destination for tourism, and hold great promise for biomedicine.

As a multi-faceted and dynamic ecosystem, the reefs are constantly changing. They face countless threats and stressors, including the effects of climate change, pollution, and overfishing; the reefs are struggling. General reef health serves as an indicator for both global and marine ecosystem health, and unfortunately, the easily observed reef degradation is representative of many other ecosystems worldwide (Burke et al., 2002).

This chapter describes coral reef ecosystems and current environmental and anthropocentric threats to coral reefs in Southeast Asia. Because of reefs high value to Earth and indigenous groups, conservation is essential; reef restoration efforts will also be highlighted. The following sections will detail the dynamics, threats, and benefits of the Southeastern Asian coral reefs, while focusing on indigenous interactions and their reef reliance.[MLH: what should the read know and be able to do after reading this?]

4.1.2 Coral Functioning

Coral [MLH: is composed of? tiny animals referred to as polyps. These polyps] work together [MLH: by the thousands–unclear] to build reef ecosystems. Each coral polyp uses calcium and carbonate ions that have been dissociated in the surrounding water to create calcium-carbonate (limestone) skeletons.[MLH: create graphic?] During the day, these vulnerable, nocturnal creatures protect themselves by hiding in their limestone skeletons. At night, they extend their many tentacles to feed, using specialized cells called nematocysts to stun their prey before consumption. Coral polyps are part of the family Anthozoa,[MLH: interesting, but you might need a trick to get the reader to care about this taxonomy...] which includes sea anemones as well, explaining their similarities. Most species of coral are extremely slow growing, and the majority grow by less than an inch every year (CORAL, 2021).[MLH: good]

The majority of corals, and the ones more important[MLH: define important] for the reef ecosystem, are classified as hard corals. These corals are reef-building corals, or hermatypes. They create the calcium carbonate skeletons which support the coral reef ecosystem. The shape of these skeletons, while heavily influenced by genetic composition, is also largely dependent on the surrounding environmental conditions to which the coral is subject. In rougher water with stronger waves breaking over the reefs, hard corals tend to create a more robust,[MLH: define robust] stable shape, like a mound or coral flat. In contrast, corals in more sheltered, calmer waters can create complex shapes with intricate branching patterns (CORAL, 2021). [MLH: figure comparing them?]

The body of each coral is actually clear; the intricate colors come from single-celled dinoflagellates, or plant cells[MLH: unclear, plant cells isn't as clear as you might think and is referring to algae and bacteria, I think...] living inside the corals. This grouping of small, photosynthetic algae living in symbiosis[MLH: should we define this?] with the coral polyps are generally referred to by their colloquial, zooxanthellae. (NOAA, 2019*b*). These algae grow inside the coral and photosynthesize, providing the necessary nutrients and oxygen the coral needs to grow and survive. The coral protects the zooxanthellae with its calcium-carbonate skeleton, and via respiration, provides the carbon-dioxide needed for photosynthesis. This symbiotic relationship between coral and algae is delicately balanced,[MLH: good – I think we can reorganize to make more clear] and small disruptions can have catastrophic effects not only for the organisms involved, but also for the entire ecosystem as a whole. (Brandl et al., 2019)

Corals are incredibly slow growing[MLH: perhaps talk about why to get the reader interested?], as they require a delicate balance of nutrients and environmental conditions.[MLH: delicate balance, neat, but I think it would be useful to define this quantitively...] Most species only grow between 0.2-1 inch per year. [MLH: new paragraph, perahps create some subsubsections?]

Coral reproduction processes vary by species. Some coral species are hermaphrodites, able to produce both eggs and sperm at the same time.[MLH: diagram] Others are gonochoric and can only produce one of the two gametes. Coral larvae can be formed either inside the polyp body or outside the polyp body, such as during mass gamete ejection events.[MLH: great information, but need to connect at somepoint to why the reader should care..., connect to climate change?] Coral larvae are released into the water, where they are free swimmers. They first swim to the surface, and then fall back to the seafloor where they must[MLH: why?] attach to a hard surface, like a rock or preexisting coral skeleton. Once attached, the corals begin dividing and making genetic copies of themselves. They then can begin secreting the calcium carbonate skeleton, which in turn attracts zooxanthellae,[MLH: what are these cues?] and the symbiotic relationship begins (CORAL, 2021).

For the duration of this chapter, the term "coral"[MLH: v good notation!] will be used to describe the network of polyps which comprise the visual structures of the reefs.

4.1.3 Reef Organisms and Trophic Interactions

[MLH: A wide range of species?] the reef ecosystem depends on [MLH: coral polyps], thus making them a keystone species [MLH: better?]. They provide the entire structure and habitat from many reef-dwelling creatures with their calcium carbonate skeletons. The coral polyps themselves constitute a small percentage of the total biomass of the ecosystem, as the average coral polyp is only around 1.5 cm large [MLH: and most of the mass is carbonate, right?], yet their impact is vital to the ecosystem's survival. [MLH: let's see if we can break up paragraphs to help the reader...]

Many species depend on these coral skeletons for either protection or as hunting grounds. Fish, invertebrate, and other organisms aggregate around these underwater structures, accounting for the ecosystem[MLH: âĂŹ]s dense biodiversity and high overall biomass. Some argue that the Parrotfish is another, secondary keystone species. This herbivorous fish eats algae latched onto the coral skeletons, which blocks sunlight and limits the photosynthetic abilities of the zooxanthellae.[MLH: certainly have a strong mutualism..., right?] In a sense, its niche is to "clean the coral," allowing normal function to continue. The Parrotfish is a highly targeted, overfished species, and because it fulfils an important niche, its removal negatively effects the entire reef ecosystem. This specific niche is just one of many, all which illustrate the complex relationships involved in the coral reef ecosystem and the importance of each species to the ecosystem (McClanahan and Muthiga, 2016).

These [MLH: which?] relationships can be further illustrated by an examination of the indirect actions which affect entire ecosystems and stem from trophic-level suppression, known as trophic cascades.[MLH: let's describe the process first then name it – and a diagram would be useful here] For Southeast Asian reefs, the most prolific trophic cascade exists between urchins and the orange-lined triggerfish.[MLH: diagram and then you can explain in the caption?] The triggerfish is a keystone predator and limits uncontrolled urchin expansion. Without these predators, urchin populations would explode and consume everything on the seafloor, creating urchin barrens incapable of supporting life.[MLH: diagram would be useful] These predator-prey interactions are disrupted by anthropocentric activities, mainly overfishing. As the fish are removed from the ecosystem at an unsustainable rate, the detrimental grazer effects of the urchins are exacerbated. While negative human influences will be discussed in future sections, this illustrates how interconnected reef species are the delicate equilibrium between them (McClanahan and Muthiga, 2016).[MLH: you can change the bib key to make it less icky].

4.1.4 Necessary Climate and Nutrients

Coral reefs require a delicate balance of nutrients and external conditions, which is easily upset[MLH: better word?], making them especially vulnerable. As for physical needs, sunlight is a crucial limiting factor of the ecosystem. The zooxanthellae require shallow waters with low turbidity, or high clarity. This means they generally can only survive in waters under 50 meters, mostly free of sediment and debris.[MLH: perhaps I should talk about light changes in the water column in an earlier chapter..., if you think it's useful.] The water also cannot have too many nutrients, as explosive[MLH: define...] algae growth can cloud waters and block the necessary sunlight needed for photosynthesis. Corals reefs exist in tropical climates usually, as they also need warmer waters of around 20-32 °[MLH: added degree symbol] degrees C (68-90 degrees F). [MLH: This explains the abundance – can we say this differenlty, or combine with ealier sentance?– of coral reefs in the tropical, warm climate of Southeast Asia.] Finally, corals need water with a high salinity, or saltwater concentration. They cannot survive in brackish water or estuaries, or anywhere where freshwater sources like rivers drain into the ocean (Brandl et al., 2019).

FIGURE [MLH: good idea]

4.1.5 Southeast Asian Reefs by Country

MAP TABLE

4.2 Climate Change and Its Effects on Coral Reefs

4.2.1 The Indigenous Paradox

Climate change and global warming are undoubtedly one of the biggest contributors to the loss of biodiversity and overall destruction of coral reefs. The IUCN Red List Index (RLI), a comprehensive list tracking biodiversity loss and extinction risk, identifies corals as one of the fastest declining species[MLH: communities, ecosystems?] (in terms of diversity and richness) in response to climate change (Almond and Petersen, 2020). Even all localized reef threats and pollutants were eliminated, the overarching threats of ocean acidification and rising temperatures hold the ability to eradicate reefs entirely (Keller et al., 2009).

In addition to reef eradication, climate change disproportionately effects lower socioeconomic classes[MLH: agreed, but the transition between these paragraphs is discordant...], specifically, indigenous people groups. Many Southeast Asian indigenous coastal peoples are reliant on reefs not only for food and sustenance,[MLH: bring back example from intro?] but they also have strong cultural ties to the reefs and surrounding waters. Climate change threatens these indigenous people-reef ecosystem interactions, and these threats compound other climate change-associated dangers affecting indigenous groups. As many indigenous groups inhabit harsh and isolated environments, they are highly vulnerable to the rising sea levels[MLH: because they are limited to low elevation lands?] and increased storm severity resulting from climate change. They are also often excluded from policy discussions and legislative responses to climate change,[MLH: really not part of the nation-state infastructure, I would think] further increasing their susceptibility to climate change disturbances (Lyons et al., 2019).

Oddly, indigenous groups are some of the most well-adapted and resilient groups in response to climate change as well. Knowledge of specific environments and ecosystems is passed down generationally, creating a plethora of knowledge concerning responses to environmental issues, all which can be used to combat the effects of climate change. This ecosystem expertise and resilience, coupled with their high vulnerability to climate change, creates what some call "The Indigenous Paradox."[MLH: interesting, I have never heard this term!] Indigenous groups all throughout Southeast Asia are continually ransacked by reef degradation in response to climate change, yet their complex, generational knowledge is vital in combatting climate change and reversing its current narrative.[MLH: perhaps give us a bit more info on this before the restoration part?] Indigenous peoples offer highly valuable resources concerning reef restoration, which will be discussed further in Section 4.6.3 (Lyons et al., 2019).

4.2.2 Rising Sea Level

A primary issue when discussing climate change and the ocean is rising sea levels. This is due to both melting polar ice caps and thermal expansion of water molecules caused by the rapid increase in temperature, or thermal heat, in recent years. Sea levels are projected to continue to rise 0.5-1.5 meters by 2100, undoubtedly impacting both submerged ecosystems and coastlines worldwide. (CORAL, 2021).[MLH: are there maps of water in the region?]

Brian Keller, r[MLH: R?]egional Science Coordinator of NOAA's Office National Marine Sanctuaries, and his colleagues conducted a study concerning sea level rise and its effect on corals on the Sanya Bay of the South China Sea, where they discovered a potentially unforeseen positive development: the sea level rise promoted coral growth. The previously degraded reef was able to recolonize via asexual fragmentation in response to the 16.2 Âś ± [MLH: replace with a custom plus-minus command] 0.6 cm rise over the previous 30 years.[MLH: interesting, any figure that can be used to show this? do we need to explain source of uncertainty?] Of the corals the study surveyed, 86% were under 30 years old, suggesting that the rise in sea level promoted their growth. [MLH: I wonder if –Theoretically, this makes sense–could be said in a more hypothesis testing way?]. Sea level rise increases the vertical space a coral can grow in, or the accommodation space. As the coral gets closer to the surface, growth is inhibited by temperature, exposure, and sediment, but by increasing the overall depth, growth can occur in a greater area of water. At first glance, this promising result suggests that climate change actually may benefit coral reefs in some way, but that is unfortunately not the case. Only specific coral species are suited for a rapid rise in accommodation space, which may select out other species. This leads to an increase in total growth but a decrease in biodiversity, and with organisms as vulnerable as coral, biodiversity is crucial (Chen et al., 2018).[MLH: icky bib key] Retrospective studies have also found that coral growth rates increased with sea level rise over 16,000 years ago, and then faltered as the sea level became stabilized during the Holocene (current time period, which began 11,700 years ago), but these results cannot be taken as indications of future outcomes. Coral growth capacity is likely to be inhibited by other factors, both regional and global, so an increase in accommodation space may have negligible overall impact (Keller et al., 2009).[MLH: good, perhaps talk about winners and loser in ecology in general?]

The negative effects of sea level rise on the coral reef ecosystem are relatively unquantified, yet practically accepted as true based on past events and prospective insight.[MLH: perhaps discuss as hypotheses?] Rising sea levels pose risks to coastal regions, with the threat of washing entire communities into the ocean. Such catastrophic events would undoubtedly add sediment and pollutants to the water while also physically damaging corals and other organisms with the marine debris. Community submergence would also displace people groups, causing them to either move inland or to other coastal areas. Many would likely move to other coastal areas to practice similar lifestyles, which would in turn concentrate pressure on reefs not yet affected by coastline degradation.[MLH: good points, perhaps with some examples?] Indigenous groups and other coastal communities are disproportionately threatened by sea level rise, as the already underrepresented groups will be forced off their land now not only by oppressive [MLH: even benevolent gov't have no clue what to do...] governments and corporations, but also by nature itself. These threats to coral reefs may seem distant, but they are quickly approaching realities imposed by climate change (Keller et al., 2009).[MLH: human planning horizons are inept at these types of time scales!]

4.2.3 Ocean Warming and Acidification

Climate change has already begun to negatively impact reefs in quantifiable ways that can be observed at the molecular level.[MLH: need more info before you start on fossil fuels...] Fossil fuel emissions release carbon dioxide into the atmosphere, and a third of that gas is absorbed by the ocean(Keller et al., 2009). As carbon dioxide [MLH: carbonic acid?] dissociates, it releases protons,[MLH: from water, I think?] which when added to the water, lowers the pH, making it more acidic. Since the Industrial Revolution, a 0.1 pH drop has been observed on the ocean surface, and this drop is expected to increase as global emissions continue and CO_2 [MLH: created a shortcut co2] concentrations rise. In more acidic conditions, corals struggle to efficiently create their hard skeletons (Keller et al., 2009). The carbonate ion saturation, or aragonite saturation, is crucial for skeletal growth, as the carbonate ion is one of the two necessary ingredients needed for limestone formation. The bicarbonate ion formed by the carbonic acid-carbonate interactions is unusable to corals, thus slowing skeletal growth (see figure for complete chemical process)[MLH: yes, create a figure! or use latex to create chemical reaction formula]. It is estimated [MLH: passive voice]that up to 60% of reefs today persist in waters with inadequate aragonite saturations (Ayala, 2009).[MLH: I suggest I put this into a one of the earlier chapters so you can reference this and now have to cover this in this chapter...]

The skeletons built by corals in waters lacking proper carbonate ion concentrations not only form slower but are also weaker and less robust.[MLH: diagram?] As a result, corals have fewer defenses to fight pressures and, combined with the slowed growth rates, may not be able to overcome the pre-existing stressors they face. Increasing acidification will likely cause coral production rates to fall below destruction rates, decreasing reef size and affecting the ecosystem as a whole.[MLH: is this a carbon balance/energy problem?] Additional stress from acidification and climate change only adds more threats to coral, creating a detrimental positive[MLH: might need to define what this means?] feedback loop for the already struggling polyps (Ayala, 2009).

On top of ocean acidification, as greenhouse gas emissions continue to cause earthâĂŹ[MLH: fix apostrophe]s surface to warm, the ocean warms with it. This rise in temperature is the main cause of sea level rise, due to both glacial melt and the molecular expansion of water molecules in response to heat. Ocean warming and its effects on coral reefs is still a topic requiring more research, but its effects have already begun to be observed (Almond and Petersen, 2020).

Coral disease transmission is exacerbated by higher temperatures, which will be explored further in Section 4.4.4. Unusually high-water temperatures are the main cause of coral bleaching, and as ocean temperatures continue to rise, mass bleaching events are expected to increase in both frequency and severity(Keller et al., 2009).[MLH: bleaching is from disease???] It is generally agreed[MLH: passive voice] that ocean warming will have disastrous future effects on coral reefs. In 2018, Intergovernmental Panel for Climate Change, or IPCC, reported that a mere two-degree Celsius rise in temperature will[MLH: could?] completely eradicate the coral reefs, with an estimated loss of around 99% of reefs worldwide (Almond and Petersen, 2020).

4.2.4 Coral Bleaching

Coral polyps react to warming water temperatures and other environmental stressors by expelling their algae. If the waters do not cool or the stressor continues to persist, the algae will not come back, and the coral will starve without them. The starved corals crumble into empty, white, lifeless skeletons. This is known as coral bleaching, and it has the potential to destroy entire reef ecosystems in an alarmingly short period of time (Suggett and Smith, 2020).[MLH: so we are looking at a obligate mutualism? might be useful to explain.]

Most bleaching and mass coral mortality events are driven by heat waves, which have increased with climate change and global warming. The disruption of the coral-algae symbiosis caused by the loss of algal endosymbionts is what causes the corals to pale, as the algae are responsible for coral coloring. Without their symbiotes, the corals lose the ability to feed and rapidly starve and die off. Not only does this halt further reef growth, but it also sends negative ecological cascades[MLH: good, but we used the word cascades was used already, is that going to cause confusion?] throughout the ecosystem. Many organisms' habitats are destroyed as the coral, the keystone species and ecosystem engineers, are removed (Suggett and Smith, 2020).

Coral bleaching is the net outcome of complex, multifactorial stressors working at both the cellular and ecosystem levels. At the cellular level, the accumulation of reactive oxygen species, or ROS, triggers signaling cascades prompting corals to expel their zooxanthellae.[MLH: another good place for a diagram] These ROS are both produced and accumulated in response to environmental changes and stressors. At the ecosystem and environmental level, the most common stressor is heat waves. The first-ever observed mass coral bleaching event in 1998 was driven by El NiÃśo[MLH: look up how to do tilde for latex], and rising temperatures have been accredited with the increasing frequency of bleaching events. The two recent back-to-back bleaching events in both 2016 and 2017 show[MLH: these were dramatic events, and in the news as I remember, is this useful to talk about the public nature of the events?] not only the vulnerability of the coral ecosystem to change, but also how climate change will only make coral bleaching more frequent and of greater severity. Other environmental exacerbators include, but are not limited to, light availability, salinity, oxygen demand, organic nutrient availability, and inorganic nutrient availability.[MLH: good, I wonder if we can create diagram to explain all these stressors?] While one of these single factors may not cause a mass bleaching event, they are interconnected and have cumulative effects on the fragile, not-easily-adaptable coral polyps. Each factor also can change how well coral adapts to rapid heat change. Coral bleaching is the result of a complex, dynamic system that global warming negatively affects in multiple ways (Suggett and Smith, 2020).

4.3 Unsustainable Fishing Practices

4.3.1 The Live Reef Fish Trade

Unsustainable fishing practices are arguably the most detrimental local practice to Southeast Asian reefs. Over 55% of reefs worldwide are affected by overfishing and unsustainable fishing techniques, and this number is higher in Southeast Asian reefs. Overfishing disrupts food web balance[MLH: do scientists really use balance? seems old phrase], since macroalgae, without as many fish as predators, grow disproportionality and smother corals. Overfishing has made fish harder to catch[MLH: you mean the decline in fishing stocks?], leading to a shift away from sustainable fishing practices. Unsustainable fishing threatens not only fish stocks and ecosystems, but also local economies and the people that rely on fish for food.[MLH: do we know what are the most important? and what about bicatch?] The methods currently used to catch live fish, like cyanide fishing or blast fishing, have been incredibly destructive to the coral reefs of Southeastern Asia. Both Indonesia and the Philippines offer textbook examples of unsustainable practices which still persist today, despite efforts to regulate and ban them (CORAL, 2021).

A major driver of unsustainable fishing practices is the Live Reef Fish Trade, or LRFT, which is precisely as it sounds: selective fish are caught alive and sold as high-priced delicacies.[MLH: very good, perhaps discuss in constrast to the fish for food] Certain high-commodity fish, like leopard coral reef fish, are targeted and fished for disproportionately, selectively pressuring reef ecosystems and disrupting trophic interactions. These fish can sell for as much as $60 USD per kg instead of the average $2 USD per kg for most fish. In locales such as Palawan, Philippines, where the average monthly income is under $100 USD, it is no surprise the LRFT would flourish. Fishermen explain,"It's like hitting the jackpot every time" (Fabinyi, 2010). [MLH: this looks like similar to "drug-demand and it's impact on particular regions of the world.]

Many of the practices for catching live fish are inherently destructive. Fish are often caught young and then grown to an edible size.[MLH: oh, are these used for food or for aquaria?] This excessive juvenile capture removes fish before they can reproduce and contribute back to the ecosystem, further reducing the fish stocks of the selected species.[MLH: perhaps, we need to learn more about their life history?] Other more violent methods, like cyanide and blast fishing, have horrid effects on reefs, and these will be discussed in the following sections (Fabinyi, 2010).[MLH: good reference]

The LRFT has continued to grow in both the Philippines and Indonesia despite both decreasing profitability and fish stocks. This dangerous combination has led to high levels of overfishing that further destroyed coral reefs. Fishermen are catching less fish and must travel farther distances to find them, causing large scale economic losses in both coastal communities and the individuals residing in them. Because the LRFT is poorly regulated and any existing regulations are often not enforced or disregarded, the harmful impact of the LRFT is likely to continue (Fabinyi, 2010).[MLH: good information, let's see if we can reduce the length of this section]

4.3.2 Cyanide and Blast Fishing

The selective catching of live fish is easily accomplished through the use of sodium cyanide, which stuns larger fish to be later revived. While it may sound complex, cyanide fishing is as simple as diving with a spray bottle containing crushed sodium cyanide tablets which can be injected into reef crevices or squirted directly into the faces of desired fish. While larger animals may only be stunned and can later revive, smaller organisms are severely poisoned by the cyanide, as it represents a much larger proportion of their body weight and size.[MLH: wow, nasty] These animals inevitably die, disrupting ecosystem functioning on multiple levels. Cyanide is most often fatal to small fish, invertebrates, corals, and their symbiotic algae (Pearce, 2003).

After just 30 seconds of cyanide exposure, coral becomes stressed and begins to lose its ability to function normally. It is[MLH: passive voice] estimated that for every live fish caught with cyanide, a square meter of reef is destroyed. Cyanide fishing is not only used for the LRFT, but also for aquarium trade as well. At the turn of the century, 75% of all aquarium fish coming from Southeast Asia were estimated to be cyanide-caught.[MLH: okay, both food and aquairia] It is estimated that around two-thirds of all Filipino reefs are affected in some way by cyanide poisoning (Renaud, 1997).

Despite being banned in both Indonesia and the Philippines, cyanide fishing still persists today. AsiaâĂŹ[MLH: apostrophe]s growing affinity for live fish, with neighboring countries like China and Hong Kong making up the majority of the market, fuels the continued use of cyanide fishing. The Padilla region in the Philippines is responsible for around two-thirds of all live fish exports, exporting up to a ton of fish per day. Many of these live fish are caught via cyanide fishing. The minimal regulations and negligible punishments for cyanide fishing enable this destructive practice to continue. There have been[MLH: can this be more active?] almost no convictions or case files against cyanide fishingâĂŤonly six total have occurred in six years (Pearce, 2003).

FIGURE

Blast fishing is another way to stun fish for the live trade harvest. Explosives are detonated in reefs to stun fish, which are then selectively chosen for live trade. Like cyanide fishing, smaller organisms are often immediately killed by these blasts, and the coral is as well. Because blasts also break the preexisting coral skeletons, both the habitat and entire ecosystem are destroyed.[MLH: this is crazy!] Over half of all Southeastern reefs are threatened by blast fishing practices (Fox and Caldwell, 2006).

The explosives used are almost always homemade and can be as simple as a kerosene-fertilizer mixture inside a glass soda bottle. Just one 300mL bottle can create an explosion which leaves behind a crater with a 1-meter radius capable of lasting multiple years. Besides the general fatalities from the blasts, one of the biggest issues associated with blast fishing is the leftover coral skeleton debris. An examination of craters left behind by blast fishing concluded that even after five years, the rubble and debris left inside the crater was between 5-10 cm deep. This additional sediment can smother both coral and algae, either blocking light and hindering photosynthesis or burning still-intact corals alive. Larger debris and skeletal pieces can also abrase growing corals, scraping off growing colonies or hindering recruitment by blocking secure surfaces for attachment (Fox and Caldwell, 2006). [MLH: good summary]

Over half of all Southeast Asian reefs are currently threatened by blast fishing practices. Again, like cyanide fishing, blast fishing is legislatively banned, but this ban is not adequately[MLH: seems understated?] enforced. Blast fishing was banned in Indonesia in 1985, yet it still continues today, not only in Indonesia, but also in most other reef-bearing Southeastern countries (Fox and Caldwell, 2006).

4.3.3 Economic Drivers and Indigenous Contributions

A group of indigenous peoples deeply impacted[MLH: see if you can be more specific] but also highly connected to unsustainable reef fishing is the semi-nomadic, boat dwelling communities of Southeast Asia. These maritime communities are reliant on the sea for subsistence, often inhabiting areas of high biomass and biodiversity, as resources are often concentrated there. As a result, many of these communities are situated near coral reefs and rely on them; to them, reef survival means human survival (Hoogervorst, 2012). [MLH: great, let's see if you can combine with next paragraph, to make this more specific]

One of these groups, the Sama-Bajau, reside mainly in the Philippines and eastern Indonesia. Foods derived from reefs provide a majority of their protein intake, and fishing is a dominant economic sector among the group. Most other economic activities among the Sama-Bajau relate to reefs, as reef reliance supports a wide range of activities, from boat building, to guiding tours, to sea trading. Many groups like the Sama-Bajau have modernized to incorporate stilt houses, giving them more of a sense of community and stability. Unfortunately, many other groups lack government representation,[MLH: I wonder if we can be more precise of what this means] and in turn cannot officially own land areas for settlement. The resulting highly mobile lifestyle deprives these groups of not just landownership, but also healthcare, education, and traditional economic prosperity (Hoogervorst, 2012).[MLH: as a cultural practice, it certainly doesn't align with income associated with private property. tricky to think about..., seems like you have some good stuff]

Because of the many factors contributing to indigenous suppression and poor socioeconomic conditions, the vast majority of the reef fishermen are poor and struggle to sustain themselves and their families through traditional fishing practices. One factor of interest is the drop-out rates among children in these indigenous groups. The reef-reliant, seafaring lifestyle is commonly not respected among upper socioeconomic classes, for these indigenous groups are viewed as primitive and uncivilized. As a result, indigenous children face widespread racial and cultural discrimination, leading them to drop out of school and pursue a less economically prosperous career, like fishing. As reefs are continually degraded by overarching issues, such as climate change and local issues (e.g., corporate overfishing and pollution), sustainable fishing practices become less viable. Many Sama-Bajau fishermen, like other indigenous fishermen, have turned to the more lucrative unsustainable fishing practices like blast fishing and cyanide fishing. Driven by the high demand of the LRFT and aquarium trade as well, these destructive fishing practices promise steady, higher payouts than traditional fishing methods. Indigenous participation in these activities is not driven by economic greed, but purely because they lack other alternatives to feed their families. These fishing practices further degrade reefs, putting indigenous groups in a viscous cycle of reef degradation and economic activity loss. The drivers of many of the previously mentioned unsustainable fishing practices result from a complex system of oppression, especially among indigenous groups of Southeast Asia (Hoogervorst, 2012).[MLH: great stuff]

4.4 Reefs Pollutants

4.4.1 Marine Debris and Ocean Contaminants

A significant number of anthropocentric activities contribute to reef pollution. Pollutants can be classified generally in three categories: toxins, sediments, and nutrients. Toxins cause physical harm to corals and other organisms at the cellular level. They can be organic or inorganic and are often found in chemical runoff. Sediments block sunlight and prevent photosynthesis and limit primary production. They also reduce the number of viable locations for coral larvae to attach to, as the loose sediment settles on the previously secure spots on the coral skeleton. Sediment also increases the turbidity of the water, blocking visibility. This can contribute to biodiversity loss, selecting for certain animals which do not primarily rely on eyesight. Finally, nutrients can promote algal blooms which smother corals, or they can disturb organismal balances within the ecosystem, disrupting critical interactions among populations. Nutrient increase, or eutrophication[MLH: do we need to define this?], can also promote pathogenic growth among corals and lead to coral epidemics. A wide range of human activities contribute to reef pollution, with globalization, population expansion, and development as main exacerbators (Todd et al., 2010).

Marine debris is essentially human trash, which enters the water via boats or from land. Floating trash can bear resemblance to jellyfish and is often consumed by animals, obstructing their gastrointestinal intestinal tract (CORAL, 2021). If not eaten, it also may snag corals and shade them, so that the zooxanthellae cannot adequately perform photosynthesis, and thus starving the corals. This trash entanglement also may break off chunks of coral, killing entire colonies (US EPA, 2017). Lost nets, lines, and other ghost fishing gear also often entangle corals and other reef organisms, severely hindering their mobility and often killing them. The levels of marine litter in Southeast Asia generally exceed the global average, with new coastal development, ineffective regulatory methods, and heavy shipping traffic throughout the region being main contributors (Todd et al., 2010).

The majority of marine trash is plastics, which account for 60-80% of all marine litter. Plastics take multiple generations to degrade and can act as a skin for chemical pollutants, carrying chemicals and toxins into the water from the land or anything else they were in contact with. At each successive trophic level, plastic can be ingested, as there is significant variation among the size of plastic particles. Plastics travel up the entire food chain, decreasing both energy reserves and feeding capacity. Plastic ingestion also decreases the ability to produce offspring, or fecundity. Oceanic plastic pollution is so high that it is estimated there is not a single ocean organism that is completely unaffected by plastic ingestion, either directly or indirectly (Reichert et al., 2018).

The traditional "plastic pollutant" is a macroplastic, that is, visible to the naked eye. In actuality, microplastics, or plastic particles under 5mm, comprise the majority of plastic pollution and are increasing in concentration at alarming rates. These microplastics can enter the surrounding reef waters as fragments from larger plastic debris or in terrestrial runoffs and waste dumps. They affect different species of coral differently, but each varying effect is almost always negative. They may attach to corals and disrupt cellular functioning, or they can cause excessive mucus production and overgrowth. Microplastics are small enough for corals to ingest, and the corals retain the plastic fragments for extended periods of time. Microplastic exposure may trigger signaling cascades related to cleaning and digestive responses among different coral species. In a microplastic-coral interaction study, five out of the six coral species examined displayed serious negative health effects when exposed to microplastics. In areas with higher concentrations of microplastics, bleaching and tissue necrosis was widely observed. Microplastic exposure is continually increasing, and poses a serious threat to reefs, corals, and reef organisms alike (Reichert et al., 2018).[MLH: good section]

Both sewage and wastewater discharge contribute a significant amount of toxins and contaminants to reef water. Chemicals, toxins, bacteria, and pathogens can enter reef ecosystems from cesspools, septic tanks, landfills, sewage treatment plants, and more. These chemicals have obvious negative effects on coral reefs, as many of them can either kill or infect corals and reef inhabitants (CORAL, 2021). In Southeast Asia, over 80% of sewage deposited in the ocean is left untreated, inevitably depositing high levels of toxins and chemicals into the waters (Todd et al., 2010). One of the most prevalent chemicals affecting coral reefs, however, comes not from industrial waste and sewage, but from tourists and everyday people. Oxybenzone is a common component of sunscreen, which enters the water whenever people wearing sunscreen do. Along with other harmful chemicals in sunscreen, oxybenzone damages coral DNA and also accumulates in tissues, either causing death and deformities among adolescent coral colonies or inducing bleaching (US EPA, 2017).[MLH: I wonder if you can break this up a bit?]

Another major source of reef contamination is crude oil, which blocks sunlight, smothering and starving reefs. Oil enters the ocean not only though spills, but also via operational discharge. This oil itself contains toxic components. One of these substance groups, polycyclic aromatic hydrocarbons (PAH)[MLH: can we have a diagram of these?], bind to coral DNA and proteins, and in turn disrupt necessary cellular functions (Todd et al., 2010). While the oils themselves are harmful, the dispersants used to clean up spills are actually more damaging to coral polyps. Surfactants[MLH: define] and other solvents are often used for their ability to dissolve and break apart large floating sheets of oil into smaller droplets. These dispersants are toxic to coral larvae and can kill large sections of young coral fairly quickly. They also prevent the fertilization of mature eggs and hinder coral maturation, or metamorphosis. Oil contamination and surfactant poisoning are increasing in Southeastern coral reefs, as development has continued to increase in Southeast Asian coastal regions (Shafir et al., 2007).

4.4.2 Development, Industrialization, and the Agta

[MLH: agta??]

Many coastal regions in Southeast Asia have seen rapid development in the past couple of decades. This development in itself has negative effects on reefs, as piers and other structures are often built on top of already struggling reefs, negating any chance of regeneration. Resources like sand and limestone are also sometimes extracted from reefs in a process called coral mining; large coral pieces and other reef materials are used as road fills, bricks, or cement components (CORAL, 2021). Much of this coastal development also releases high concentrations of sediment into the water, increasing turbidity and primary production within the reef. Coral reefs are continually polluted by the dredging, dumping, and shipping all associated with development as well. While development is typically a positive economic indicator, it often carries disastrous environmental side effects, as evidenced by the relationship between development and the coral reefs (US EPA, 2017).[MLH: good]

Road construction in particular generates many negative consequences for reef growth and survival. Not only does road construction release high levels of toxins into surrounding waters, but it also adds a great deal of sediment as well. Roads, as well as other impervious structures, do not allow liquids to seep into the soil. Instead, they flow across road surfaces and downward, generally towards sources of water. Even after construction is complete, runoff from coastal roads continue to contribute substantial amounts of toxins and sediment to the reefs. This is especially problematic during storms and in areas of high precipitation, as heavy rains pick up toxins and sediments from the ground and flow via roads directly into the ocean.[MLH: we could put this in critical zone, to save space in your chapter?] Both Indonesia and the Philippines host monsoon climates, and because this stormwater cannot be filtered by the soil, it carries all of its pollutants into the reefs. Notable toxic substances reaching waters in greater quantities include metals like lead or mercury or organic chemicals like polychlorobiphenyls (PCBs).[MLH: diagram?] This particular carcinogenic dioxin not only takes a long period of time to break down, but also affects the growth rates, feeding patterns, defensive responses, and reproductive processes of all coral species. As road, industry, and urban development persist, the runoff will continue to carry chemicals, toxins, sediment, nutrients, and pathogens into surrounding reef water (US EPA, 2017).

In addition to reef degradation, development and industrialization has often displaced indigenous groups. Development indirectly undermines indigenous groups by harming reefs, but also directly hurts them via displacement and relocation. One of these groups, the Agta people of Northeastern Luzon in the Philippines, perfectly exemplify this scenario. Over the past decades, infrastructural development has displaced many of the Agta, forcing them to live as landless peasants on the outskirts of other towns and villages. Much of the Agta lifestyle consists of spearfishing the shallow reefs of their native waters, and as they are pushed further inland, they cannot continue their traditional practices. Instead, they must adopt different livelihoods, and turn away from their ancestral reef reliance, breaking the longstanding cultural ties and connections to the water (Persoon and Minter, 2020).[MLH: great! can we add a bit more detail and then genealize about various policies that have worked/failed?]

4.4.3 Deforestation and Agriculture

As the Agta[MLH: oh, this a group of people? some background might be useful] are continually forced inland, they must find new economic activities to sustain themselves. The most commonly chosen new livelihood is small-scale, swidden agricultural cultivation. Slash-and-burn technique is used to clear areas for farming, contributing to both deforestation and agricultural issues in the near-coastal forests. Both are contributors of reef pollutants, further harming the already struggling reef ecosystems and the other indigenous coastal groups who still rely upon them (Persoon and Minter, 2020).

Deforestation adds high levels of sediment into the surrounding waters, smothering coral. Corals and their endosymbionts in sediment-filled water cannot carry out nightly respiration or daily photosynthesis in an efficient manner. In Indonesia, palm oil plantation growth is a major contributor to deforestation, while in the Philippines, the expansion of logging and agriculture industries is the main cause. In both countries, corruption, poor regulation, and economic greed have exacerbated this issue. One specific tree of interest is the mangrove, which is particularly important to reef protection. Many reef fish raise their young in the protected labyrinth of the mangrove forest, and without it, many offspring become easy prey. In addition to the traditional consequences of deforestation, mangrove destruction also means nursery loss. Mangrove forests also act as filtration systems for sediment, and without them acting as a barrier, more sediment from runoff and other human activities reaches reefs. Three quarters of the mangroves in the Philippines have already been lost, and as agriculture continues to expand, this number is likely to rise (CORAL, 2021).

Agricultural runoff also adds sediment to reef water, but more importantly, agricultural runoff adds excess nitrogen, phosphorus, and other nutrients. Generally, having more nutrients is beneficial, but the reef ecosystem is adapted to survive only at specific, lower-nutrient levels. Nutrient excess selects for other organisms like seagrass, however, which boom in population and outcompete corals for their required nutrients. This eutrophication stems mainly from runoff and discharge containing manure, fertilizers, aquaculture byproducts, and pesticides. Manure and other fertilizers cause phytoplankton booms which not only block sunlight but can also create toxins that are dispersed throughout the ecosystem. These massive algae blooms also require tremendous oxygenic support, causing hypoxic conditions in the water surrounding them. The already struggling organisms often succumb to hypoxia and die off in mass quantities. When pesticides reach the waters, they generally disrupt the symbiotic coral-algae relationship. Herbicides in particular are very dangerous, as they kill the algae and induce bleaching. Finally, when corals are exposed to too many nutrients, bacteria and other pathogenic growth are promoted. Diseases and coral contamination quickly follow (Todd et al., 2010). [MLH: let's put this in with land use or critical zone. Let's meet with Sam to see what she thinks.]

4.4.4 Coral Diseases

Corals are highly susceptible to diseases. They lack virtually any dispersal barriers and spread rapidly due to how close in proximity coral colonies are to each other. Viruses, bacteria, and fungi can cause diseases among coral species, which all proliferate with temperature increases and lower water qualities. As a result, global warming and other anthropocentric activities have led to an increase in coral diseases(Keller et al., 2009).

Pathogens often enter the reef water through runoff and stormwater containing fecal matter, inadequately treated sewage, and other contaminants. One of the major human sources of coral diseases, however, is plastics. Pathogens attach to micro-holes in plastics, and when they reach the reef, the pathogen can disconnect and then reattach to the polyps.[MLH: do we know the identity of these diseases?] A coral that has been in contact with any plastic is twenty times more likely to be infected with a disease than one that has not. For Southeast Asia, a region with an estimated 11 billion plastic reef entanglements, this is a major issue. Reefs that have no plastic exposure have a 4% lethal coral disease probability, which, while still high, pales in comparison to the 89% lethal disease probability of plastic-entangled reefs.[MLH: is there a way to use as a figure or table?] Plastic entanglement can potentially create perfect conditions for viruses and bacteria, as sunlight and oxygen may be blocked, and temperatures can increase in sort of a greenhouse effect. As certain coral species are more likely to snag plastics than others, plastic-induced pathogens also contribute to biodiversity loss among coral species (Thompson, 2018).

Though the methods of transmission are well-theorized, the exact pathogenic causes of coral diseases are not fully understood.[MLH: not fully understood or totally unknown?] The effects of coral diseases are nevertheless clear. Diseases always present some sort of indicator, including red, black, white, or yellow bands, discolored spots and blotches, or rapid degradation and general tissue loss. Coral diseases also cause large coral chunks to slough off, exposing the calcium carbonate skeleton underneath. After the area is exposed, small reef creatures inhabit it, using it for shelter and breeding. This over-colonization thus cannot be regrown with new corals, so instead of only the chunk dying, the entire colony passes with it. Very little treatment is available for coral diseases, as currently, black-band disease is the only treatable disease. Coral diseases pose great threats to reefs, as they are not easily combated and can spread rapidly through entire ecosystems (NOAA, 2019*a*).[MLH: could we get a figure?]

4.5 Reef Ecosystem Services

4.5.1 Biomedicine

Coral reefs host a vast array of human benefits, which helps to explain why they have been so overused and exhausted. Coral reefs hold massive medical potential, though currently that field of biomedicine is lacking and underdeveloped. As stationary animals, corals need chemical defense mechanisms to protect themselves from predators. These chemical defenses also help to fight diseases and combat environmental stressors. Ideally, one would be able to replicate these chemical processes in drugs for humans to use as defenses to diseases and illnesses. Coral medicine is still in the early stages of development; its importance comes mainly from the potential it holds (Bruckner, 2002).

Coral reefs have been referred to not just as the medicine cabinet of the sea, but the medicine cabinet of the 21st century.[MLH: seems like a strange metaphor...] These natural underwater pharmacies are genetic warehouses and hold colossal medical potential. Forty to fifty percent of all drugs currently used have natural origins, and coral reefs are estimated to have 300-400 times higher drug potentials than their terrestrial counterparts (Bruckner, 2002). New medicines to treat cancer, arthritis, AlzheimerâĂŹs, heart disease, viruses, bacterial infection, and more are currently being developed with corals as the centerpiece. Other reef organisms like the seahorse have traditionally been used in alternative medicine (CORAL, 2021). In 14th century Asia, seahorse extract was used to treat infections and pain, as well as respiratory, circulatory, and sexual problems. The medical contributions of the reefs have long histories, but it is their potential that holds the most promise (Bruckner, 2002).

With this great potential comes complications, however. Research and development into coral reef biomedicine are lacking and underdeveloped and will require a great deal of time and resources. While potentially preventing the next global pandemic or treating chronic diseases justifies the costs, the threat research may pose to corals is troublesome. Corals, as small and slow growing organisms, struggle to provide the adequate amount of product or a substance needed for research and development. While any type of harvest or removal poses potential risks to the already struggling corals, too much removal is sure to harm corals. Reefs hold massive medical potential, but any research must be conducted in an ethical and sustainable manner (Bruckner, 2002).

4.5.2 Food Sources

Despite only making up 1% of the ocean, coral reefs support over a quarter of all fish in the ocean (NOAA, 2019*b*). They are densely populated regions which provide food to people around the globe. It is no wonder six million fishermenâĂŤa quarter of the world's small-scale fishermen, actively fish the reefs (CORAL, 2021). Coral reefs provide both employment and food for the vast majority of the 350 million people living within 50km of Southeast Asian coastlines. In addition to harvesting food, reefs fisheries are vital economic players in Southeast Asia; fisheries generate over 2.4 billion US dollars every year. Indonesia and the Philippines dominate the majority of this revenue, as the total annual economic benefit is estimated at USD 1.6 billion and USD 1.1 billion, respectively. Fisheries compose the largest section of these earnings, and their true revenue is often underreported, as small-scale, sustainable fishermen often do not report reef catches in monetary values. These fishermen and their families are generally reliant on reefs for substance, and thus are more impacted by reef degradation (Burke et al., 2002).

Fish and seafood from the reefs, on average, make up around 40% of total animal protein intake for Southeast Asian diets, explaining why fishing in the Coral Triangle has continued to increase as global rates have flatlined. The Coral Triangle includes Indonesia, the Philippines, Papua New Guinea, the Solomon Islands, and Timur-Lee, but a majority of the coastal people living in the Coral Triangle reside in either the Philippines or Indonesia. Fish-related employment makes up 2% of the entire working population in the coral triangle, a whopping 4.6 million people. Over 18 million people, or 5% of the total Coral Triangle population, directly rely on reefs for food. Fishing has been estimated to account for over 5% of the gross domestic product of the countries in the Coral Triangle.[MLH: map] The densely populated reefs rich with fish provide food for all types of people, from the average consumer shopping at a market to the indigenous person fishing purely for personal sustenance.[MLH: are there any dietary studies w/ details] Nevertheless, reef fisheries are crucial to sustaining Southeast AsiaâĂŹs large and growing population (Palma et al., 2014).

All socioeconomic groups across Southeast Asia are reliant in some way on coral reefs for food sources, however, lower classes are often more dependent on reefs for sustenance. The indigenous peoples of Southeast Asia are one of these heavily dependent groups. The Tagbanua People offer a case study on reef reliance representative of many other indigenous groups in the Coral Triangle. The Tagbanua People, or the People of the Village, inhabit Coron Island, Palawan on the Southwestern side of the Philippines. Thought to be descendants of the Tabon Man (16,500-year-old remains foundâĂŤ the earliest appearance of modern man), the Tagbanua are one of the oldest groups in the Philippines. They occupy a coastal region and have a very close relationship with both the water and the reefs (Capistrano, 2010).

The Tagbanua have been categorized as a semi-nomadic, seafaring native group. After agriculture, fishing is the second main economic activity. A vast majority of fishermen practice either traditional hook-and-line fishing or spearfishing and take only what is needed from the reefs. They fish both for personal sustenance and trade, but they donate excess catches to community members in need whenever possible. Tagbanua fishing is highly sustainable, as they hold high respect for the reefs and its inhabitants. As reef degradation continues, millions across Southeast Asia lose access to food and protein sources, but more directly dependent groups like lower socioeconomic classes and indigenous groups are disproportionately affected (Capistrano, 2010).

4.5.3 Tourism and the Tagbanua

Reefs attract tourists for various recreational activities. Shallow waters and high levels of biodiversity make for world-class snorkeling and diving. For the same reasons, boat tour charters and submarines also thrive from reef tourism. Coral reefs attract spear fishers as well, as there are many fish species which can be shot and caught, all while in relatively shallow water. Because reefs are natural breakwaters, they create world-class, incredibly consistent waves, which attract surfers from around the globe. Almost every world-famous wave breaks over the reef, and the shallow reef waters provide fast, hollow waves perfect for barrelsâĂŤevery surfer's dream. Bali, Indonesia, is just one example of a destination which attracts surfers of all skill levels solely to surf the reef-breaking waves (Almond and Petersen, 2020). Over 9% of all coastal tourism value is attributed to the coral reefs. They provide many incentives for travel, and this tourism brings both positive and negative effects (Spalding et al., 2017).

Globally, reef tourism is estimated to generate USD 36 billion yearly, and the mean value of reef per square hectare is thought to be around USD 96,000. Many recreational reef activities have been commercialized. Cn-reef tourism helps to stimulate and support local economies. The general appeal of reefs has developed strong tourist economies in the Southeastern coastal areas. This reef-adjacent tourism, including hotels, rentals, restaurants, and more, has created additional jobs and stimulated economic growth. 30% of the worldâĂŹs reefs are involved in the tourism sector, and they provide employment to over one hundred different sectors. The importance of reef tourism has provided economic incentives for reef conservation and sustainable practices. Tourism provides opportunities for conservation education and great awareness, which allows issues to be displayed on a global scale instead of only in local communities. Tourists may also become emotionally attached to reefs, providing additional incentives to support reef restoration and protection efforts, either directly or financially (Spalding et al., 2017).

While tourism does aid in economic development, it also can lead to heightened economic disparity and steal wealth from local communities. Foreign corporations and large companies often dominate tourist areas, making it so local people cannot own businesses, but instead must work for them. As tourism can be such a dominating economic force, it can also edge out other economic sectors, and large corporations can easily obtain monopolies on entire regional economies. This allows them to mistreat and underpay their workers, who are typically mainly local people (Spalding et al., 2017). Reef tourism has also contributed to countless culturally insensitive developmental projects, which negatively affect the indigenous groups, including the Tagbanua. They are consistently pressured to lease out their land for tourism purposes, as their “pristine” surroundings are easy selling points. Tourists who have come close to indigenous lands have left pollutants and contributed to reef degradation, further harming native populations. As reefs are continually degraded, native peoples are continually harmed. The TagbanuaâĂŹs recent self-determination and land reclamation efforts are complicated by tourism and the economic greed that accompanies it. The reefs surrounding indigenous lands are highly desired, as they have not been subject to as many unsustainable practices. It is very difficult for indigenous groups like the Tagbanua to become involved in the “democratic process however,” as previously only those who are formally dressed and speak fluent English are allowed to attend and participate in policy dialogues. As a result, indigenous groups can be purposefully underrepresented and their land is commonly encroached on, a practice exacerbated by tourism and perfectly exemplified by the struggles of the Tagbanua (Capistrano, 2010).

Tourism also contributes heavily to marine degradation and reef destruction. It breeds development, as hotels, piers, roads and other structures are built to accommodate tourists. This development adds sediment and other contaminants to reefs, as previously discussed in Section 4.4.1 (Spalding et al., 2017). Tourists themselves can also harm reefs during their on-reef recreational activities. They may step on corals while diving and kick up sediment while snorkeling. Tourists often are also not environmentally conscious, and they leave behind trash which pollutes reefs. They may wear chemically harmful sunscreen while in the water, leaving pollutants and chemicals in the reefs (CORAL, 2021). From buying unsustainable coral jewelry to accidentally spearing an endangered fish, tourists themselves can threaten reefs in countless ways. Tourism as a whole can be beneficial or detrimental to reefs, depending on how it is implemented, who holds the power, and how well-educated the tourists are (Spalding et al., 2017).

FIGURE

4.5.4 Coastline Protection

Worldwide, over 200 million people depend on coral reefs for protection from storm surges, rough waves, and flooding (Almond and Petersen, 2020). Waves break over patches of shallow water, and because reefs extend vertically up the water column, they serve as natural breakwaters. They reduce the power, size, and energy of waves (Beck, 2019). Reefs have been shown to reduce wave energy by up to 97%, and wave height by 84%. Waves first break over the shallowest part of the reef, the reef crest, which alone can dissipate around 86% of a waveâĂŹs energy. Without reefs, waves would break over sandbars closer to the coast, flooding terrestrial settlements and destroying dwellings.

(Pelton, 2017).

In addition to acting as breakwaters, reefs provide buffers for coastlines against floods, storms, and erosion. Southeast Asian reefs protect billions of dollars worth of coastline, as reefs continue to dissipate wave energy during natural disasters. In the monsoon climates of both Indonesia and the Philippines, typhoons occur often, and without reefs as protectors, coastlines would be hit significantly harder. Reefs protect coastlines not just from typhoons, but also from hurricanes and tsunamis. The global cost of storm damage is estimated to double without reef protection. The submerged reefs are crucial natural defense systems, protecting millions of coastal inhabitants in Southeast Asia and around the globe (Beck, 2019).

4.5.5 The Sentinelese People

[MLH: great!]

MAKE A BOX

Another Southeast Asian indigenous group in close relation with the reefs are the Sentinelese people of the Indian OceanâĂŹs North Sentinel Island. This group drew international attention when they killed an American tourist who travelled on their land illegally, and then shot arrows and threw spears at the helicopter sent to recover his body. It is estimated[MLH: passive voice] that there are between 80-150 people currently living on the island, and they are one of the last untouched native peoples. Their sovereignty is protected by North Sentinel IslandâĂŹs lack of natural harbors and the surrounding sharp, shallow reefs. The Indian government has also enacted laws protecting their sovereignty, leaving them very isolated from foreign interference (Smith, 2018).

While little is truly known about the Sentinelese, their relationship with the reef is relatively understood. Their hunter-gatherer lifestyle is mainly fueled by the reefs. They use small, narrow, outrigger canoes and long poles to navigate and harvest the shallow reefs in the surrounding waters. A vast majority of their consumed protein comes from the reefs; they fish, harvest, and consume both reef fish and invertebrates. It can be assumed that many other Southeast Asian indigenous groups in coastal areas maintain a similar relationship with coral reefs, though they may lack government protection. Reef degradation is often viewed solely in ecological terms, but we must also consider its anthropologic effects, especially on indigenous populations (Smith, 2018).

4.6 Reef Restoration, Protection, and Conservation

4.6.1 Ecosystem Based Adaptations

Coral reefs, in their current state, cannot be restored passively. It is not enough to simply stop the problems and threats corals reefs face; the extent of current degradation cannot be repaired. Active restoration efforts are critical for the future survival of the corals and the coral reef ecosystem. The implementation of ecosystem-based adaptations and formation of marine-protected areas have been two highly successful active restoration efforts. Reef restoration is a complex, dynamic task that requires community involvement, government backing, foreign aid, and restorative projects that are backed by research and driven by science (Westoby et al., 2020).

Ecosystem-Based Adaptations, or EbAs, are a form of active coral restoration which aims to rebuild natural capital and ecosystems in order to aid in preservation and protection, while also promoting and defending vulnerable ecosystems, like the coral reefs. The first EbA restorative efforts took place in the reefs of the Philippines, but they have since been expanded for worldwide use. In Southeast Asia, EbA are still very prevalent and have had great success when it is properly implemented. It is mainly carried out at the community level but offers involvement opportunities to a wide range of people and groups, from tourists to NGOs to scientists and more. EbA, especially in Southeast Asian coastal communities, drives co-benefits between people and nature, as reef restoration coincides with economic growth and prosperity (Westoby et al., 2020).

Coral gardening is a widely used EbA composed of two phases. In the first, the nursery phase, corals are grown via asexual coral propagation. Coral colonies that have already been destroyed or broken off, or corals of opportunities, are harvested and brought to nurseries where they are grown for the next 6-12 months. Nurseries can be either ocean-based or land-based. Ocean-based nurseries are cheaper but more vulnerable, while land-based nurseries resemble labs and are more expensive and protected. During this phase, a hundred colonies can easily become thousands, which are then implanted directly into the reef (Lirman and Schopmeyer, 2021). A newly emerging and highly successful type of coral gardening is microplanning. Newly grown colonies are commonly arranged a few inches apart from each other on a rock-like base and subsequently doused with a growth elixir in a lab. The corals grow up to 25 times faster and connect to form one massive colony, which is then later transplanted into a living reef ecosystem (Morin, 2014).

Another EbA, direct transplantation, involves transplanting broken corals to other locations without first growing them in a nursery. This strategy is often employed after storms, as rough waters and waves may break pieces of coral away from their main structure, and the corals cannot survive without anchoring. Colonies are then relocated to areas with more inhabitable conditions where they are more likely to survive and reproduce. After this more suitable area is identified, fragmented corals are secured with cement or steel ties. Corals need stable, secure structures, which are achieved either by cementing a colony onto a cement base and then attaching this base to the seafloor with cable ties or by just simply attaching cable ties to corals and then driving them into the seafloor to act as anchors. Direct transplantation also applies to the second phase of coral gardening. EbAs commonly overlap and build off each other to achieve the best restorative results (Scott, 2018).[MLH: can we make a table of restoration techniques?]

Artificial reef creation, another EbA, has seen high levels of success in reef restoration. For a reef to be artificially made, pre-existing materials like oil rigs and other large steel or concrete structures, are sunken in reef areas and act as anchors or attachment zones for reefs to form. As reef restorative technology has progressed, artificial reef creation has progressed with it. Mineral accretion devices such as Biorock have been very promising and hold great potential. These electrified artificial reefs are essentially metal webs with weak electric current flowing through them, which not only prevents rusting but also causes minerals to precipitate out of the water and collect on the metal. The attached coral colonies can in turn make calcium carbonate skeletons three-to-five times faster than before, as they have an abundance of substrate and easy access to it as well. Mineral accretion devices also protect corals from bleaching and other external disturbances, making them highly effective options for artificial reef promotion. They are expensive and hard to maintain, however. Because of the funding and expertise required, mineral accretion devices are difficult to implement at a local level without an external partner (Scott, 2018).

Reef restoration via EbAs is by no means cheap, but it is a necessary step in coral reef protection and restoration. The benefits far outweigh the costs, for future issues stemming from a lack of coral reefs will cost more fiscally and harm already struggling populations. EbAâĂŹs require significant government support, which is harder to obtain in the developing coastal countries of Southeast Asia than in developed countries. Developing countries have fiscal advantages, however, as restorative efforts are estimated to be thirty times cheaper than in developed nations, because community and volunteer participation significantly lower costs.[MLH: has anyone tried to create a tourist tax for restoration?] Case studies in both Indonesia and the Philippines confirmed that local participation and community involvement not reduced costs of restoration, but also contributed to long-term benefits in sustainability and within the community (Westoby et al., 2020).

4.6.2 Marine Protected Areas

Marine Protected Areas, or MPAs, are areas that purposefully restrict human activities in effort to either promote conservation or restoration. They give fish and other reef populations areas to recover, as they cannot be affected by overfishing and other unsustainable practices. As coral conservation efforts continue, the specific areas of the Indo-Pacific have been made MPAs, which have led to significant positive reef growth and restoration. The Philippines Marine Sanctuary Strategy of 2004 declared that 10% of coral reefs would be no-take MPAs by 2020, but currently, only 2.7-3.4% of reefs are MPAs. On top of this, 85% of the Philippines MPAs are concentrated in only two areas, leaving them highly susceptible to ecological disturbances (Weeks et al., 2010). MPA networks have been deemed more effective than single, large-area MPAs, as disturbances concentrated in one area, like an oil spill or heat wave, will not destroy the entire implemented MPA system. Smaller networked MPAs are also more easily managed locally, a vital component of MPA effectiveness. A large, singular MPA may stop an entire community from harvesting reef resources, making multiple small MPAs much more suitable options when still considering anthropocentric factors(Keller et al., 2009). Finally, effective MPAs must be adaptive, as reefs are constantly changing, but also must be long-term and well-enforced. MPAs are much more easily enforced when local communities and governments are involved with the decision-making process and implementation, as shown by Locally Managed Marine Areas, or LMMAs. LMMAs are not managed in the traditional top-down style with a national government presiding over the area, but instead are managed at local levels in conjunction with local traditions and community practices. In the Indo-Pacific, regions where LMMAs have been implemented have led to high levels of reef renewal and restoration (Lirman and Schopmeyer, 2021). When MPAs are properly implemented and effectively managed, they have been proven to be highly successful. IndonesiaâĂŹs Convention of Biological Diversity and Sustainable Development Goals pledged to turn 32.5 million ha, or 10% of the total coral reefs, into MPAs. A study conducted across 622 Indonesian coral reefs spanning 17 geographic regions concluded that successfully implemented MPAs had significantly higher biomasses (1.4 times higher). In general, reefs need a measured biomass of 500-650 kb/ha to sustain functionality, and this was accomplished in around 40% of all Indonesian MPAs surveyed. In contrast, only 25% of open reefs were above this threshold. Both no-take and gear-restricted MPAs promote biomass by providing safe spots for struggling reef populations to recover without external, anthropocentric threats. This allows fish and other reef populations to better recover from overfishing and other unsustainable activities, further stressing the importance of MPAs (Campbell et al., 2020).

One less common type of MPA results not from governmental restrictions, but indigenous efforts. To many indigenous groups, particular reef sections are culturally significant, and some waters are even thought to be sacred. One of these groups, the already-discussed Tagbanua, believe some nature spirits, or Panyain, dwell in reefs. Panlalambot, a giant-humanoid octopus, is one of these reef-dwelling Panyains that inhabits a reef section in off Coron Island.[MLH: neat, is there a figure?] As a result, these areas are highly protected and act as fish sanctuaries, allowing certain struggling populations to recover from the many unsustainable practices and pollutants effecting marine ecosystems. While these "MPAs" are culturally motivated, they are still highly effective and beneficial to reef restoration efforts (Capistrano, 2010).

4.6.3 Intersectional Efforts

While local management and grassroots projects have been highly effective, they must be paired with involvement by national government and programs in order to enact effective, long-lasting reef protections and restorative efforts. These intersectional efforts are vital to reef restoration efforts, as local communities hold extensive ecological knowledge about specific reefs of their area. Intersectional efforts also maintain an environmental justice lens, as both environmental and anthropologic factors are considered in policy making. This protects already marginalized groups like the indigenous people of Southeast Asia, for purely environmental efforts often disproportionately affect the groups more directly reliant on a specific ecosystem. When consulted in policy making, indigenous groups are not only given their deserved voice, but also offer generational knowledge concerning reefs which has been expanded upon for over a millennium. These indigenous groups and local communities also do not share the same financial or lobbying ties and biases as other groups may. Generally, they want what is best for the reefs, as it is best for themselves as well. This anthropologic lens developed through this intersectionality is crucial to maintaining a just, inclusive approach to ecological restoration (Lyons et al., 2019).

IndonesiaâĂŹs Coral Reef Rehabilitation and Management Program, COREMAP, perfectly illustrates this collaborative effort between national government and local communities. Started in 1998, COREMAP began by aiding local community management of coral reefs but has since significantly widened its scope of practice and nationwide impact. COREMAP has successfully implemented over 350 collaborative management plans between local communities and governments, increasing awareness about ocean health and the threats coral reefs face. Through COREMAP, rare and endangered species have been able to rebound and have returned to reefs. In six of the seven project districts, COREMAP policies and initiatives lead to a 17% growth in coral cover, as well as a 20% income growth among district residents, clearly illustrating that coral restoration drives economic prosperity (Aquino and Kaczan, 2019).

The national scale COREMAP operates on allows for a wider range of capabilities achievable by purely local-level projects. Their intersectional nature, however, allows for local community voices to be heard and accounted for, and marginalized groups to be represented. COREMAPâĂŹs involvement with local communities also allows for a better implementation of policies, as the groups involved have personal ties and motivations for restoration. For example, interventions such as the 2004 Blast and Cyanide Fishing ban can only be implemented at the national level but has had issues with implementation and enforcement. National bans and legislation are useless if they are not followed, but because COREMAP promotes community engagement, its projects have been highly successful. It is initiatives like this, backed by both national power and local participation, that are critical to the protection and restoration of the coral reefs (Aquino and Kaczan, 2019).

4.7 Coral Reefs: Conclusion

FIGURE

From localized threats, like unsustainable fishing and pollutants, to global threats such as ocean acidification and climate change, coral reefs are highly threatened. These biodiverse ecosystems support millions across Southeast Asia; not only do they provide food and protection, but many coastal economies are directly reliant on reefs. Threats to reefs are threats to people, especially to already struggling poor coastal communities and indigenous groups of Southeast Asia. Indigenous groups are commonly disproportionately affected by reef destruction, as they are more directly reliant on them. Reef degradation in turn is not simply an ecological issue, but an environmental justice one was well. Pollutants and malpractices must be eliminated, but reefs will also require active restoration efforts, as anthropocentric actions have degraded reefs to the point where they are no longer capable of healing independently. Saving the coral reefs is not saving a few fish species; it is saving millions of organisms and the millions of people who rely on them. Coral reef conservation should not be viewed simply as an ecological issue, but as a complex problem requiring multidisciplinary efforts to achieve success.

[MLH: let's put these figures in the sections above. . .]

Table 4.1: Southeast Asian Coral Reef Size by Country

(a) :Listed are some notable Southeast Asian countries and their respective reef areas. While Indonesia and the Philippines dominate total reef area, many coastal Southeast Asian countries have reefs of their own, all which face similar anthropologic pressures. Southeast Asia accounts for over a quarter of all the worlds coral reefs (Spaldin et al., 2001).

Country	World Reef Area Ranking	Reef Area (sq km)	Percentage of World Total Reef Area (%)
Indonesia	1	51,020	17.95%
Philippines	3	25,060	8.81%
Malaysia	17	3,600	1.27%
Japan	23	2,900	1.02%
Thailand	26	2,130	0.75%
Myanmar	27	1,870	0.66%

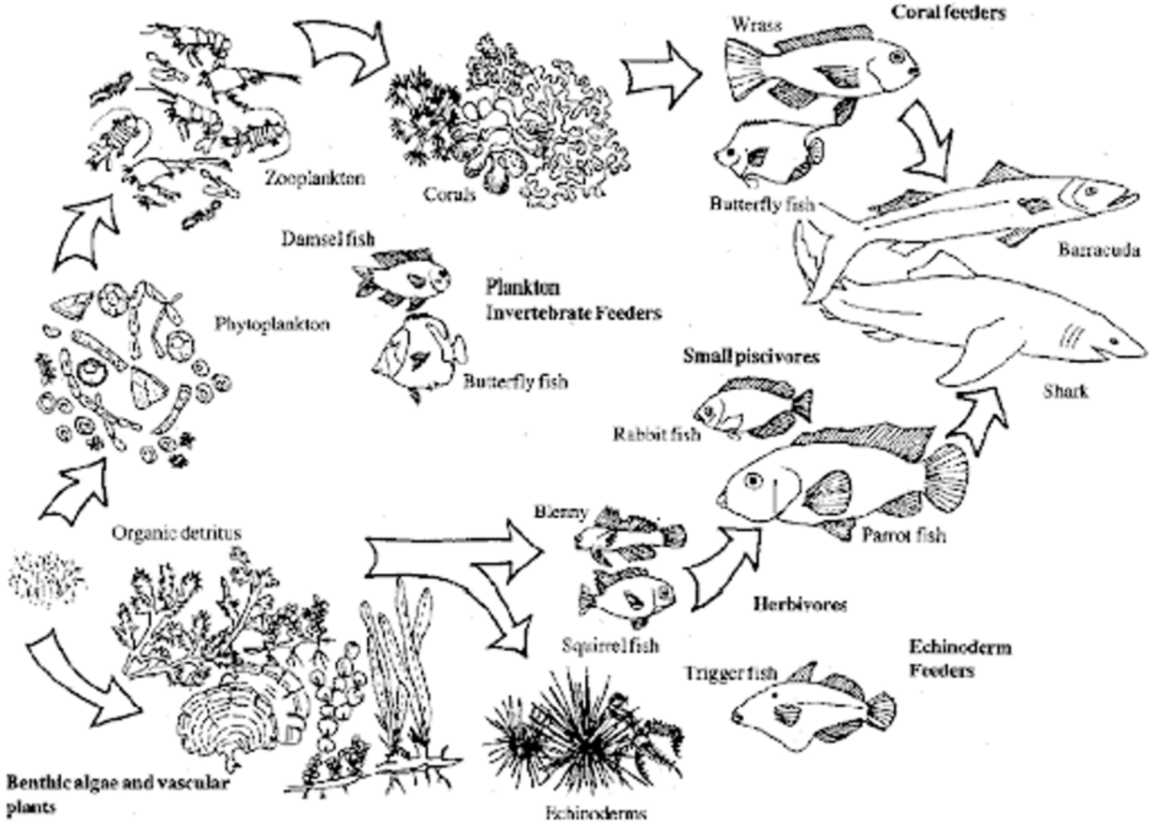


Figure 4.1: The coral reef food web, or the relationship between successive trophic levels of the community, starts as any other food web, with energy being derived from the sun by primary producers via photosynthesis. These primary producers include seaweed, grass, phytoplankton, and perhaps most importantly, the zooxanthellae coral symbiotes. This is the largest group, as only about 10% of the energy in each trophic level is passed to each successive level. The second trophic levels, the primary consumers, includes zooplankton, mollusks, squirrelfish, urchins, and of course, the coral polyps themselves. Following this are the secondary consumers, made up of triggerfish, Parrotfish, butterfly fish, and more. Finally, tertiary consumers like the reef shark and barracuda finish this food web, with detritivores like sea cucumbers or bacteria decomposing and recycling organic matter back into the ecosystem (McClanahan and Muthiga, 2016).

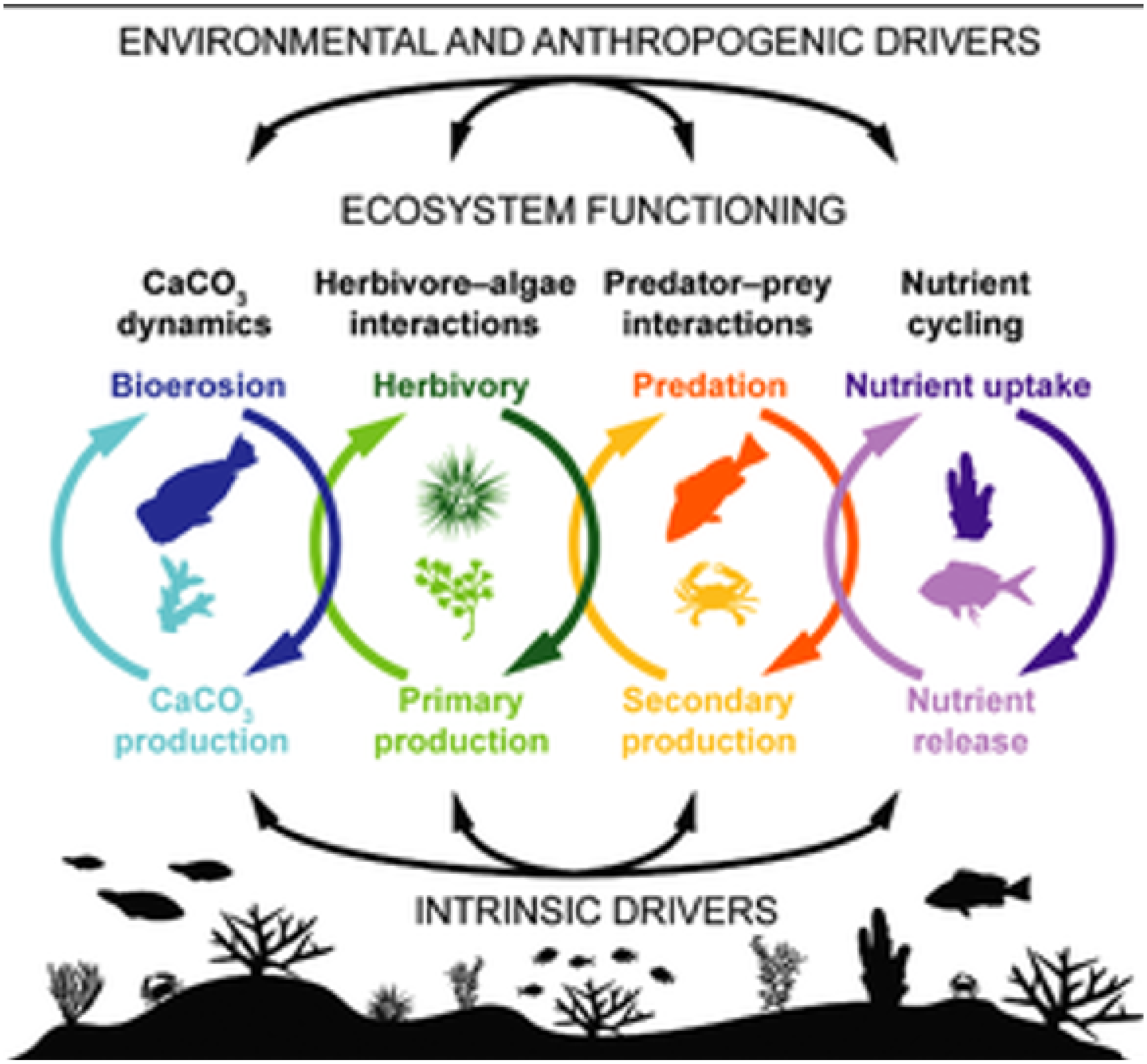


Figure 4.2: The above cycles and reciprocal processes are vital for coral growth and survival. The first, blue cycle, calcium carbonate dynamics, is directly correlated with the coral skeleton formation. Bioerosion, or the breakdown of hard oceanic substrates, leaves behind calcium and carbonate ions, which coral polyps use to produce their limestone skeletons. The second, green cycle, herbivore-algae interactions, involves both primary production and herbivory. Photosynthetic organisms transform sunlight into chemical energy, which is then moved up in trophic levels by herbivores. A balance between the two must be maintained to prevent explosive growth of lower trophic levels, which in turn could suppress crucial processes carried out by other organisms in the ecosystem. Predator-prey interactions, the orange cycle, also regulate explosive trophic level growth, as successive trophic level limits the prior. Again, the balance keeps the biomass of one species from dominating and smothering other species. The final process driving success within the coral reef ecosystem is the purple cycle, nutrient cycling, or the uptake and release of nutrients among the organisms of the ecosystem. Nutrients must be moved efficiently and effectively in cycles, with a balance maintained between retention and reintegration (Brandl et al., 2019). Figure from: (Brandl et al., 2019).

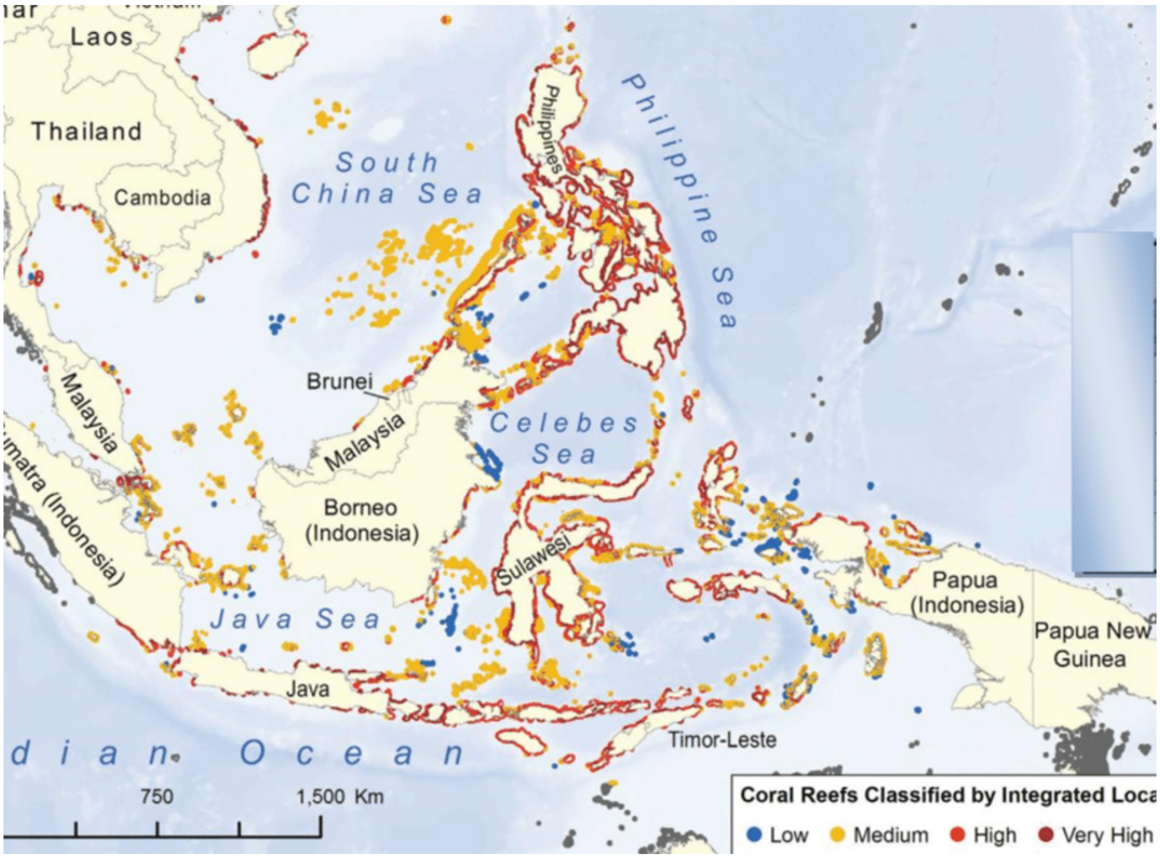


Figure 4.3: Coral reef locations are relatively limited, as the previously mentioned conditions must be satisfied, yet they can be found in over 100 countries, mainly between the Tropics of Cancer and Capricorn. As seen above on the map, reefs are concentrated in shallow waters surrounding many islands of the Indo-Pacific. Reefs surrounding both Indonesia and the Philippines compose a majority of not only Southeast Asian reefs, but also reefs worldwide. Coral reefs cover 284,300 square kilometers (110,000 square miles) worldwide, yet the overall area of healthy reef is decreasing rapidly (Spaldin et al., 2001).

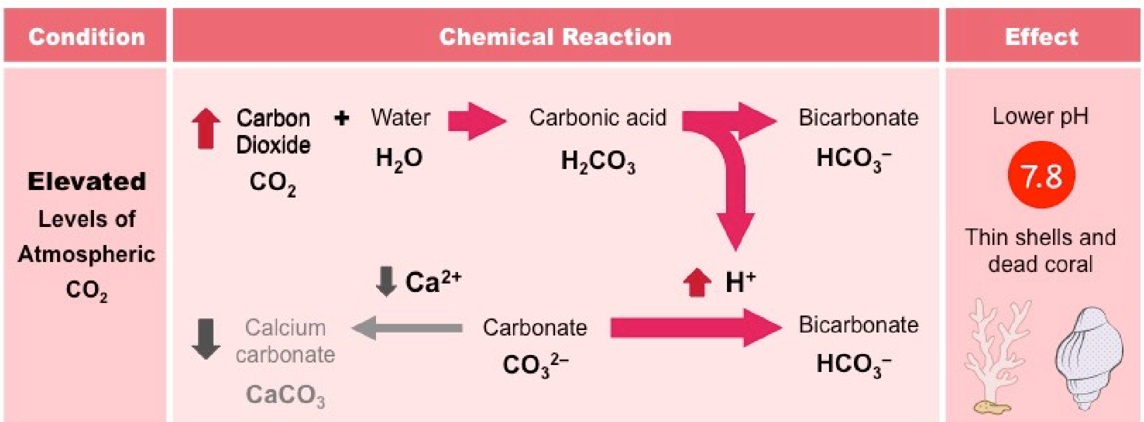


Figure 4.4: The above figure outlines the chemical reactions which connect ocean acidification with limestone formation. As carbon dioxide dissociates in the water, it creates carbonic acid, or H_2CO_3. The protons of carbonic acid are easily dissociated by the more polar water molecule (H_2O), thus dissociating and combining to form bicarbonate, or HCO_3. The dissociated protons may also form bicarbonate by reacting with carbonate ions. This chemical reaction removes carbonate ions from the water, which corals need to construct their calcium carbonate skeletons.

Figure 4.5: This above split-image shows the same fire coral before (left) and after (right) coral bleaching has occurred. The vibrant colors on the left image result from the zooxanthellae symbiotes, and when the corals expel them, the ghostly white color seen on the right image is observed. This color change is universal across all coral species; only the color of the calcium carbonate skeleton remains after the algae are expelled.

Figure 4.6: :The diver in this picture is cyanide fishing in a Filipino reef. He uses cheap, makeshift gear which can be either made from scrap or repurposed. The warm, coastal waters allow him to dive without a wetsuit, only using wood planks nailed to slippers as fins. His bottle contains crushed sodium cyanide tablets dissolved in water, a lethal solution which will decimate the reef he is injecting it into.

Figure 4.7: :This picture shows a brain coral that has been infected with black-band disease. The left side of the coral is how healthy coral appears; the right side is diseased. This particular coral diseaseâĂŹs name is derived from the black circumferential band in the middle of the coral. As the disease progresses, the band travels along the coral, killing polyps and leaving behind a dying, empty skeleton (seen on the right half of the coral).

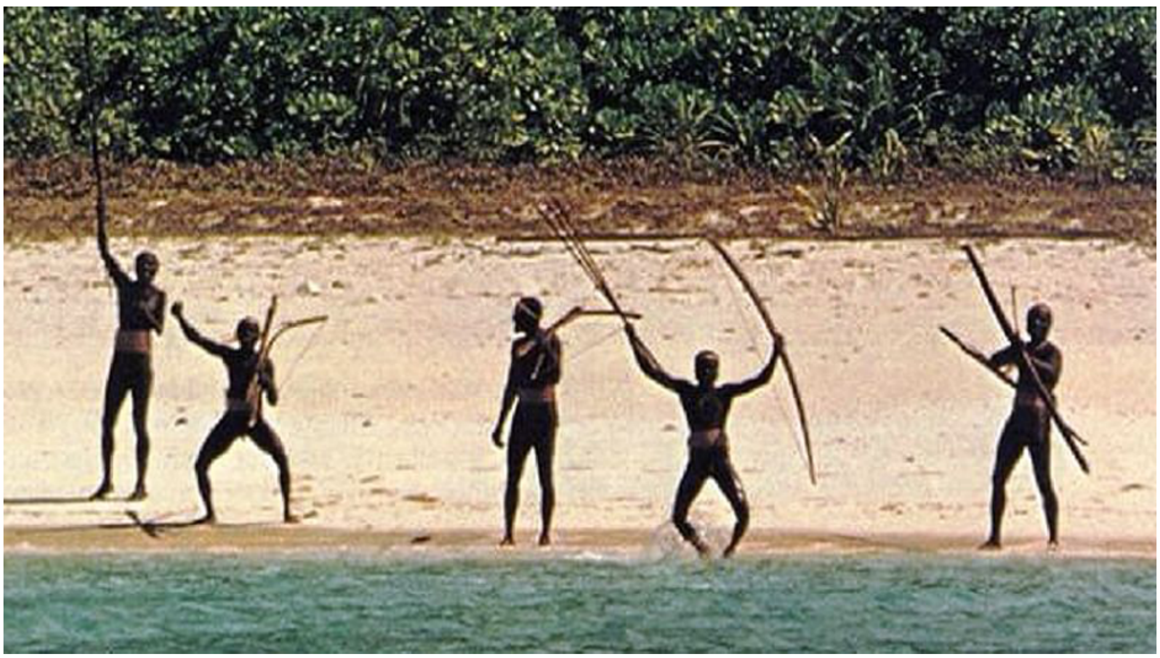


Figure 4.8: :The Sentinelese people are pictured above. When this picture was taken, they approached the bank and began making threatening advances towards the cameraâĂŹs direction. The man on the far left throws a spear while the man on the far right readies an arrow. This hostility towards outsiders has allowed to Sentinelese to remain one of the last untouched indigenous groups in the world.

Figure 4.9: :The 12-15 million indigenous people living in the Philippines make up between 10-15% of the population. 110 groups are officially recognized, yet there are many more who have not been officially recognized by the PhilippinesâĂŹ government (Capistrano, 2010). Above pictured are the Tagbanua, one of these indigenous people groups of the Philippines. They either spearfish or fish from simple wooden boats like seen above. These boats are used to traverse the shallow reefs and harvest fish, lobster, squid, octopus, and other protein sources. Many other indigenous groups maintain a similar reef-relationship, one consisting of simple fishing practices, and transportation methods (Capistrano, 2010).

Figure 4.10: :Pictured is a healthy Southeast Asian coral reef. Bursting with color and biodiversity, reefs like these support lives for thousands of species, including humans. Reef restoration and protection are crucial to maintaining already thriving reefs like this and also reviving the many degraded reefs of Southeast Asia. Reef conservation will allow these coral reefs to remain rich in biodiversity and continue sustaining the indigenous peoples and coastal communities of Southeast Asia.

Chapter 5

Waste Management for a Circular Economy

5.1 Life-Cycle

5.1.1 Collection

5.1.2 Transport

Treatment

Disposal

Sectors:

Industrial

Household

Biological

Types of Waste:

Solid:

Liquid

Gaseous waste

5.2 Biomimicry

5.2.1 Circularity

Examples in Nature

Education:

Teach people to be mindful and live sustainably

Social PsychologyProblems and New Approaches:

Sustainability

Incineration & Dumping

Recycle & Reuse

Resource Recovery

Chapter 6

Air Pollution & Social Justice in Hong Kong

Neenah Vittum

6.1 Opening

6.2 A Brief Overview of Hong Kong

6.3 Hong Kong's History

6.4 Air Pollution in Hong Kong

6.5 Air Pollution and Human Health

6.6 Population Density, Income Inequality, and Housing

6.6.1 Income Inequality and Zoning Laws

6.6.2 Public Housing

6.6.3 Economic Mobility

6.7 Indoor Air Pollution

6.8 Open Spaces and Other Patterns of Environmental Inequity

6.9 Environmental Activism in Hong Kong

6.10 Beyond Hong Kong

6.11 Beyond Hong Kong

practicing with Nora

Figure 6.1: caption

Chapter 7

Plastic and Packaging in Japan

7.1 Introductiona and Goals?

Plan: Use Japan's unique plastic packaging as a lens to view plastic waste management. I can bring in benefits of their plastic use, like cultural significance of beautiful wrapping and food safety, and then discuss plastic pollution as a larger issue in East Asia, bringing in examples of blame placing, and of course discussing potential solutions on both international and local scales.

7.2 Plastic Pollution and Waste Management in East Asia

7.2.1 Statistics/comparisons

graphs and images will help with perspective

7.2.2 History of plastic waste issues in East Asia

Are specific companies/industries responsible responsible

what kinds of plastic waste are there (sector break down)?

Where in the world did the ubiquitous usage of single use plastics come from?

General blame placing/biases/rhetorical

examples of discourse around plastic waste in East Asia. Why does any of this matter(needs its own section)?

Plastic waste trade?

https://link.springer.com/article/10.1007%2Fs10163-004-0115-0

https://www.sciencedirect.com/science/article/abs/pii/S0956053X20305602

Blame placing through both rhetoric and scientific studies

(this source is a very data based study that concluded that the vast majority of plastic pollution comes from a few sources in Asia/Africa... I want to explore what they might not have taken into account when collecting data)

https://science.sciencemag.org/content/347/6223/768

https://pubs.acs.org/doi/10.1021/acs.est.7b02368 https://www.dw.com/en/whose-fault-is-plastic-waste-in-the-ocean/a-49745660 (found the two above studies through this article)

Japan Specific (I need to break these into hierarchies of significance), some sections, the first few will be more data based, the second half will be more rooted in sociological primary sources.

Waste management issue overview

Sector Break Down/ responsible parties in Japan

Impacts of plastic pollution on different groups within Japan

Cultural significance of wrapping

Food safety

Gov action/recycling/current efforts

Activism

Potential solutions moving forward rooted in current activist efforts/respect to culture

https://www.pnas.org/content/117/33/19844.short

https://www.jstor.org/stable/432317?seq=1

https://onlinelibrary.wiley.com/doi/abs/10.1002/1099-1522(200003/04)13:2%3C45::AID-PTS496%3E3.0.CO;2-%23

Part I

Backmatter

The back matter often includes one or more of an index, an afterword, acknowledgments, a bibliography, a colophon, or any other similar item. In the back matter, chapters do not produce a chapter number, but they are entered in the table of contents. If you are not using anything in the back matter, you can delete the back matter TeX field and everything that follows it.

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