

# Variations in Vulnerability to Climate Change in Southeast Asia

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## Introduction

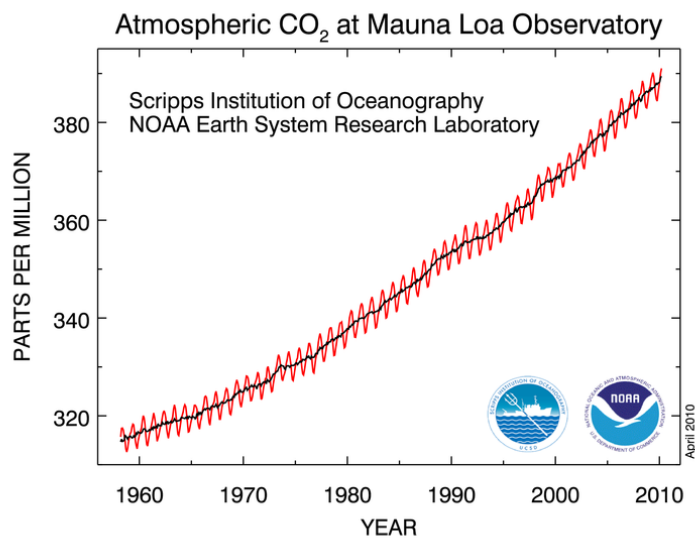
The importance of studying the effects and consequences of global climate change has begun to be acknowledged by most people. As more research is done and more evidence is found supporting a human impact to global climate change, nations are becoming more serious in supporting and implementing changes towards a more carbon-free and environmentally-sustainable way of life. While global climate change will affect all areas on earth, certain areas are more prone to disaster. The powerful western nations (including United States, Canada, and most of Western Europe) who are most responsible for global climate change will not experience the same magnitude of consequences as poorer and developing nations. "...The developing world, by virtue of its relative poverty and lack of technological infrastructure, is far more vulnerable to economic, environmental, and health threats posed by climate change" (Mann 191). One of these areas that is highly vulnerable is Southeast Asia, a region made up of many small island countries and characterized by widespread poverty.

Vulnerability to climate change is a somewhat relative term, but generally refers to the amount of negative consequences possible that arise from global warming for a certain area. There are many aspects that make Southeast Asia increasingly vulnerable to the threats of climate change. Climate impacts on small islands and coastal areas include a rise in sea level, an increase in natural disasters, and the increase in sea surface temperatures (which can act as a catalyst to more natural disasters). Other factors that are important to discuss in this region are demographic characteristics including poverty in the nations, lack of resources, and increase in disease. While these are not only very real human issues, they could also increase the vulnerability of the area and amplify negative climate consequences. Studying each of these

characteristics of vulnerability will increase the ability to act responsibly and appropriately to best help this area.

### Global Climate Change

To begin, an understanding of the meaning of climate change and global warming is necessary. Put very simply, climate change and global warming can be used interchangeably and is defined as “a long-term shift in the statistics of the weather” that causes substantial disruptions in human and natural systems (“NOAA National Weather Service”). After many years of collecting data and measurements, the general trend seen is increasing global mean temperatures, and a predicted increased warming of 1.5 to 4.8 degrees Celsius over the next 100 years (Ward, 38). Global climate change in itself has been happening since the formation of Earth, and is not new to scientists (Ward, 7). What makes recent climate change important and unique is the source of temperature change and rate of change. The main source of the recent temperature change is largely believed to be from the increased use of fossil fuels. Fossil fuels are defined as “deposits of carbon, primarily in the form natural gas, oil, and coal” (Rohli, 17). Fossil fuels are the primary source of energy for transportation, appliances, factories, and most other industries. When fossil fuels are used, carbon dioxide and other gases (greenhouse gases) are released into the atmosphere. While there are several different greenhouse gases (most too insignificant to mention called trace gases), the ones that are most important in the atmosphere are carbon dioxide, ozone, water vapor, methane, and nitrous oxide. The role of greenhouse gases in the atmosphere is a process known as the Greenhouse Effect. These atmospheric gases absorb energy that is radiated from the earth (longwave energy) and re-radiates some of that energy back towards the earth’s surface (Rohli, 17). This reemitting of energy keeps the earth warmer



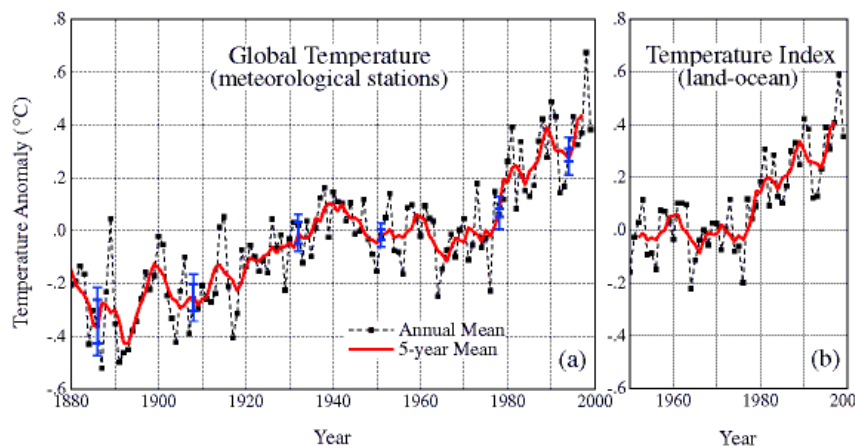
**Figure 1:** Monthly mean atmospheric carbon dioxide measured at Mauna Loa Observatory, Hawaii

than it normally would if there were no greenhouse gases in the atmosphere (Rohli, 17). However, increasing the amount of greenhouse gases in the atmosphere would also increase the Greenhouse Effect, resulting in an abnormal amount energy being re-radiated back towards the earth's surface. This is exactly what has been

measured; this non-natural increase of greenhouse gases in the atmosphere is what is most important in the study of global warming.

On the Hawaiian Islands in 1957, climatologist Charles Keeling began to measure the amount of carbon dioxide in the atmosphere (Rohli, 17). Hawaii is an excellent location to study the atmosphere because its location is too far from any type of local or regional bias (Ward, 17). As seen in Figure 1, the amount of carbon dioxide in the atmosphere has steadily increased for the past 50 years.

Increased fossil fuel consumption is the main reason for this increasing trend in greenhouse gases. Figure 2, another graph displaying the impact of greenhouse gases that is



**Figure 2:** (a) Near-global annual-mean surface air temperature change, based on meteorological station network, (b) global land-ocean surface temperature index, which combines sea surface temperature measurements for ocean areas with surface air temperature measurements at meteorological stations.

created and distributed by the National Aeronautics and Space Administration (NASA), shows the warming of the earth in terms of global temperature. If one were to compare Figure 1 and Figure 2, there is a very close relationship between the increase in carbon dioxide and the increase in global mean temperature. While no one is able to say that fossil fuels are the absolute cause for an increasing global temperature, it is important to note the relationships to aid in the continued research.

Since the discovery of the relationship between greenhouse gases and an increase in global temperature, there have been numerous studies to try and predict the possible implications of a warming earth. Some of the studies conducted are region based—looking at a specific area and assessing the possible consequences of a warmer temperature for that particular location. This same process will be used to explore the potential negative results in the region of Southeast Asia. Looking at all aspects of this area (scientific and demographic) will give an understanding of the vulnerability of this area and bring up possible changes that could be made today to bypass the intended consequences.

### Southeast Asia

The region Southeast Asia is composed of several countries including Indonesia, Thailand, Malaysia, the Philippines, Cambodia, Vietnam, Laos, Burma, Brunei, and Papua New Guinea (Warr, 283). Every country in this area is unique and has its own individual needs and concerns, but for the purpose of this study, generalizations will need to be made. Many specific examples given will be from the nation of Indonesia, but most of the information is also relevant for all other nations in Southeast Asia. To begin, a discussion of the physical geography, current demographics, and world standing of these nations is important.

The Southeast Asian region is made up of island nations and coastal nations connected to



**Figure 3:** Political map of the region of Southeast Asia

the Asian continent (See Figure 3).

Following the theory of Plate Tectonics, Southeast Asia is located along the boundary of two plates: the Indo-Australian Plate and the Philippine Plate.

The convergence of these two plates creates a subduction zone, where the denser plate (Indo-Australian Plate) is forced under the less dense plate (Philippine Plate) forming deep ocean trenches (Rand McNally, 12). These

island nations are also along what is called the “Ring of Fire,” which is a circle of volcanoes surrounding the Pacific Ocean (Baerwald, 49). Deep trenches can reach so far that they weaken the Earth’s crust and allow magma from lower layers to be brought to the crust, forming and building islands. Another aspect to the formation of these volcanic islands is due to hot regions deep within the Earth’s second layer, the mantle (Baerwald, 51). Magma rises from these regions in columns to produce underwater eruptions, which also harden and form small islands (Baerwald, 51). These islands still have active volcanoes and are very prone to earthquakes due to their location along the plate boundary.

This region consists mostly of tropical rain forest, and some tropical grassland in the interior continental nations. (Baerwald, 638). The proximity to the equator (ranging from 10° south to 20° north) creates a very humid, and wet climate with heavy rainfall all year round

(Baerwald, 638). The nations located on the mainland of Asia (Burma, Thailand, Cambodia, Laos, and Vietnam) are affected by the seasonal monsoons during the months of June, July, and August and are characterized by humid weather and very heavy rainfall (Baerwald, 638). Vast rainforests cover the land with a very large variety of plant and animal species unique to the region. The amount of trees grown here (balancing the oxygen and carbon dioxide ratio in the atmosphere) and the possible medicinal uses of these unique species makes these tropical rainforests very valuable.

A pattern of outside influence from China, Europe and the United States is very much a part of Southeast Asia's history. Much like other areas in the world, Europe colonized Southeast Asian nations and steadily changed their economy forever (Baerwald, 703-704). Europeans took advantage of this area's raw materials and used the local labor force to produce cash crops, such as coffee, tea, tobacco, latex, and rice (Baerwald, 703). Over time, Europeans eliminated the local craftsmen, and this region became dependent on outside influence for economic, governmental issues, and overall livelihood—they were no longer independent (Baerwald, 704). This change can still be seen today as many of the region's governments are corrupt and use similar tactics as the European powers did on the local people.

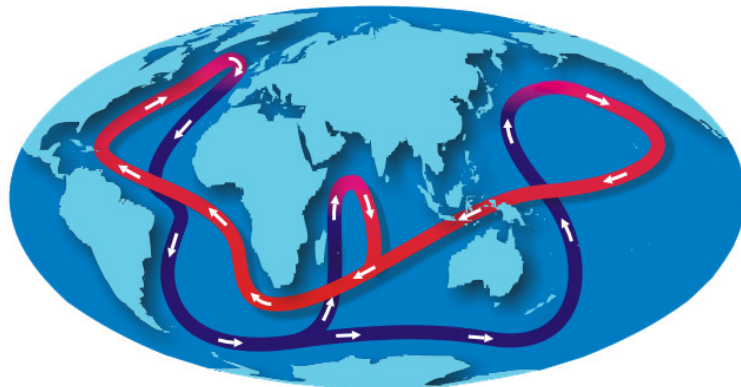
Today, Southeast Asia is one of the most densely populated areas in the world, with most people living along the coastline ("Rural Poverty in Indonesia") and in the lowland areas ("Indonesia"). The population of Indonesia in July of 2009 was over two hundred and forty million people, ranking number four of the most populated nations in the world ("Country Comparison: Population"). Half of the population lives on about two dollars per day ("Indonesia"), classifying them as poor. The amount of rural poverty and urban poverty in 2002

was 21.1 percent and 14.5 percent, respectively (Warr, 283). This area is known as a developing nation as they continue to build their resource base and independence from developed nations.

According to scientists studying future climate, “small island states are likely the countries most vulnerable to climate variability and long-term climate change” (Ebi, 1957). Among the several consequences resulting from climate change, the most influential ones in this region are, increasing sea surface temperatures, rising sea levels, changes in weather patterns, and an increase in the amount and strength of natural disasters. Looking at each individual projection will help to gain a better understanding of this area’s future.

### Rising Sea Surface Temperatures

The rising temperature of oceans surface is an important element in global warming. The ocean is of huge importance to all climatic phenomena that occurs. It has a moderating effect on regional and coastal weather, it’s the main source of moisture for precipitation, it’s the main the driving force behind most extreme weather, it plays a key role in the carbon cycle, and it’s an important transporter of water around the globe. The surface layer of the ocean is the main absorber of carbon dioxide from the atmosphere (Ward, 5). The carbon dioxide that enters the ocean is an essential part of the microscopic marine life or phytoplankton, and eventually works its way into the shells of other small organisms, also known as plankton (Ward, 5). When the plankton die, their shells sink down to the ocean floor, where the carbon dioxide is deposited into



**Figure 3:** Great Ocean Conveyor Belt



long-term storage of calcium carbonate and eventually turns into limestone (Ward, 5). The amount of carbon dioxide absorbed by the ocean depends on the temperature of the water and how quickly the oceans mix the top and bottom layers (Ward, 5). Warmer surface water has less ability to absorb carbon dioxide than colder surface water does (Mann, 96). Warmer surface water also releases more carbon dioxide in the atmosphere than colder surface water does. Increasing the amount carbon dioxide in the atmosphere would increase the atmospheric temperature, also increasing the surface water temperature, which would allow less carbon dioxide to be absorbed and more to be released—this is a positive feedback.

Another important aspect of rising sea level temperatures is the ocean circulation known as the “Great Ocean Conveyor Belt” (GOCB). Shown in Figure 4, the GOCB is an illustration of thermohaline circulation, which is a large-scale current continually moving all over the globe (Ward, 4). Several elements combine to drive this global circulation in order to bring cold, salty water from the deep ocean and mix with the warm, less salty water on the surface (Ward, 4). This circulation is of great importance to climate patterns around the world. For example, The United Kingdom and Ireland Island would have a very different climate if it weren’t for this circulation. Warm water in the Atlantic Ocean moves north from the Caribbean up into northeastern Europe, warming and moderating the weather drastically. If one were looking merely at latitude, Great Britain is at similar latitude to Siberia, Northern Canada, and Alaska. But, because of the warm water, this island is very different from these other locations, making it much less extreme conditions and much more livable.

The upwelling and downwelling of water also happens in the Pacific Ocean in a similar fashion to that in the Atlantic Ocean. Cold water from the South Ocean near Antarctica travels east and north to the Pacific Ocean. Upwelling then occurs, and warm water takes the cold

waters place by traveling back southwest into the Indian Ocean. This circulation is so important that if anything were to disrupt it, the climate around the globe would be dramatically altered. Past climate records suggest that the Younger Dryas period, a period sometimes seen as a mini ice age lasting only for about one thousand years, was caused primarily because of the thermohaline circulation was slowed or even completely stopped in the Atlantic Ocean. Reasons for this are not completely understood but a plausible idea is that a large amount of fresh water from melting continental glaciers was deposited into the ocean, reducing the density of the water dramatically and not allowing downwelling to occur. This disruption stopped the normal warming effect on North America and Europe, causing glaciers to form over the northern half of North America (reaching as far as North and South Dakota) and much of Northern Europe. Another effect that came from this stop in circulation is a possible large release of carbon dioxide in the atmosphere. Looked at earlier, the ocean is very important as it absorbs and stores a lot of carbon dioxide. Much of the carbon dioxide is taken to the deep ocean due to this circulation of down welling of warm surface water. If the down welling of cold water was halted, the natural storage of carbon dioxide would also be altered, and could potentially release the carbon dioxide into the air instead of storing it.

Another possible cause of changing the surface temperature of the ocean is the probable release of methane and carbon dioxide stored up in hydrates or clathrates (Ward, 6). Hydrates are located in the permafrost regions of the high northern latitudes and form in very cold water under these thick layers of ice (Ward, 6). Creating cage like structures, hydrates store gases like methane and carbon dioxide that has been absorbed by the ocean. Hydrates require very specific amounts of heat and pressure in order to form and be contained, if this balance was tampered with, it is possible for large amounts of these greenhouse gases to be released all at once,

creating even more warming of the atmosphere at a very fast rate (Ward, 6). Methane is a much more potent and efficient greenhouse gas than carbon dioxide—twenty three times more effective. Any release of methane is harmful, but a large release of this greenhouse house could be catastrophic.

All of these oceanic processes lead to the fact that the temperature of the ocean is a very important factor to global climate. If for some reason, the down welling of warm water or the upwelling of cold in the Pacific Ocean were to be adjusted, it could drastically alter the climate in areas further down the circulation path, mainly the Indian Ocean and Southeast Asia. While much is still to be known, the ocean is a very sensitive entity and will to be continually studied so better predictions can be made about our warming globe.

### Rise in Sea Levels

Sea level varies by region and results from a combination of factors including salinity, winds, ocean circulation, and geographical variation of thermal expansion (Ward, 39).

According to the Intergovernmental Panel on Climate Change's (IPCC) *Third Assessment Report*, "the rate of global mean sea level rise averaged between 0.1 and 0.2 meters during the 20<sup>th</sup> century," which is ten times the average rate of the last three thousand years (Ward, 40).

The two main mechanisms that are responsible for the rise in sea level globally are the expansion of ocean water as it warms (also known as thermal expansion), and the melting of glaciers and icecaps (Ward, 39). While thermal expansion is a natural process that has always occurred, it can act as a positive feedback (a situation where some effect causes more of that same effect to occur), so that when the temperature of the water is raised, it creates even more rise in sea level. Like with thermal expansion, increasing global climatic temperatures will increase the amount of

melted continental glaciers (mostly in Greenland and Antarctica), adding to the sea level rise (Mann, 98).

Albedo is also an important player in the melting of continental glaciers. Albedo is a measure of reflectivity of a surface, values ranging from 1 to 0. 1 would refer to an object that is a perfect reflector and that absorbs nothing (a close example is ice), and 0 refers to an object that is a perfect absorber and reflects nothing (a close example is water). Generally speaking, an object that is dark in color has a low albedo (close to 0), where an object that is light in color has a high albedo (close to 1). Continental glaciers are made up of ice and have a very high albedo. However, when an area on the glacier melts away, the darker ground surface is exposed, which raises the albedo of that area. The exposed ground will absorb more heat, and warm up the area surrounding it, melting more of the glacier. This is another example of a positive feedback that relates to the rise in sea levels.

The projected sea level for 2100 is anywhere from .5 meters to 1.2 meters (Mann, 98). While the amount of change seems very small, there are many serious implications, mostly effecting small island nations. One example of extreme vulnerability to the rise in sea levels is the chain of islands in the Indian Ocean, the Republic of Maldives. Maldives is an archipelago of 1,190 islands with an average elevation of four feet, or about 1.2 meters (Schmidle, 40). An article written for New York Times Magazine investigates this nation's limited options to inevitable rise in sea levels: either find a way to stop the increasing sea level, or leave the island and find a new home for the people of Maldives (Schmidle, 40). As announced in 2009, the President of Maldives, Mohamed Nasheed, is working hard to make Maldives the first carbon-neutral country in the world (Schmidle, 40) in order to slow or stop the rise in sea level. As positive as these statements sound, it is important to note that even if all the greenhouse

emissions produced by Maldives were to stop, there would not be enough change to stop the rise in sea level. The reason for Maldives to become carbon-neutral is considered to be more of a symbolic action than anything else—inspiring and encouraging other nations to move toward the same direction.

Many island nations face a similar fate to that of Maldives and are forced to make nationwide changes immediately to prevent the possible consequences. Of the ten nations that make up Southeast Asia, four are composed of islands (Indonesia, the Philippines, Brunei, and Papua New Guinea), and five have significant coastlines (Burma, Thailand, Cambodia, Malaysia, and Vietnam). As mentioned earlier, a large percentage of the population and infrastructure is located near the water, causing problems even if the sea level were to rise based on the most conservative figures of .5 meters.

### Weather Patterns

Other possible affects of global warming in Southeast Asia include the change in regional weather patterns. Changes in the weather patterns for Southeast Asia have already been observed, as atmospheric temperatures have been increasing decadal at a rate of about .1° Celsius (Ebi, 1958). Future projections, however, have shown much more rapid increases with best estimates increasing atmospheric temperatures of 2.1° Celsius by 2050 (Ebi, 1958). The warmer the atmosphere, the more likely it is to evaporate water from the surface. In areas with continual wetness and warm temperatures (like the Southeast Asian tropical rain forest), evaporation happens around the clock, which is the reason for the large amount of precipitation. If the air were to warm even more, it would increase the ability to evaporate water, which could also increase the amount of precipitation.

Another way to view this change in precipitation is to look at one of the natural oscillations of the climate system, the El Niño Southern Oscillation (ENSO). ENSO comprises two events that alternate and effect changes in sea surface temperatures, ocean currents, and wind patterns (Mann, 90). An El Niño event is characterized by the spreading of warm water over much of the tropical Pacific Ocean surface due to the trade winds weakening or even disappearing (Mann, 90). Warm water reaches as far as South America, causing the coastline up the Pacific to have higher than average amounts of rainfall (Mann, 90). On the other hand, the areas of Australia and Southeast Asia experience a lower than average amount of rainfall (Mann, 90). During a La Niña event, the trade winds are stronger than usual and cold, deep water around the coast of South America is up welled and creates a high-pressure area where less than average rainfall occurs (Mann, 90). Warm water stays more west than normal, creating more than average rainfall in Australia and Southeast Asia (Mann, 90). These two events change about every five years, and last anywhere from one to three years each.

There is some indication that ENSO may be highly sensitive to increased greenhouse gas concentrations (Paeth, 266). While there is still a lot of uncertainty in this area, it is possible that due to the increase in global temperatures, the pattern of ENSO could also be altered (Mann, 91). Because ENSO is a very important influence on regional patterns of temperature and precipitation, it is necessary to consider the possible changes and investigate it more (Mann, 91). If El Niño events were to become more frequent, there could be increased drought in Southeast Asia (Mann, 91). If La Niña were to occur more often, there could be increased precipitation and flooding in Southeast Asia (Mann, 91). Events of drought can cause loss in agricultural productivity, deterioration of soil fertility, disease, and even famine (Ward, 11). In the case of more than average precipitation, many negative effects can occur. Soil moisture budgets could

change (Ebi, 1959), meaning the soil could receive more water than it can handle, drowning vegetation and causing it to die. Also, with more precipitation, there is a greater risk for flooding to occur in lowland areas (Mann, 90). Because many people live in lowland areas due to the availability of water and land for agriculture, a flood can destroy housing, infrastructure, food resources, and human lives. Other possible consequences can be mudslides, often wiping out entire villages. Animals are also very vulnerable to climate change, especially the unique species that live in the tropical rainforests in Southeast Asia. The IPCC report states that “twenty to thirty percent of plant and animals will be subject to increased risk of extinction if global temperatures rise by 2°C” (Mann, 119). Extinctions are irreversible, and a small change can have very long lasting effects and damage an entire ecosystem. Changes in local weather could have several negative impacts to this region.

### Increase in Natural Disasters

Another very important element of the possible effects due to climate change is the increasing amount of natural disasters. A natural disaster is defined as a “naturally occurring event, which can directly cause severe threats to public health and/or well-being” (“Natural Disasters”). Natural disasters listed on the U.S. Department of Health & Human Services website include earthquake, fire or wildfire, flood, dam failure, hurricane, high wind, landslide, thunderstorm, tsunami, volcano, extreme cold, and extreme heat (“Natural Disasters”). When reviewing the aspects of climate change mentioned earlier, like increasing the atmospheric temperature and rising sea levels, an increase in natural disasters seems very plausible (Ward, 72). If there are warmer temperatures, the atmosphere will become more unstable and more likely to evaporate water. More available moisture on the ground could also increase the amount

of water evaporated. If these two things are to occur, there could be much heavier rainfall than before causing possible flooding and dam failure. Also, with warmer sea surface temperatures comes the possibility of hurricanes increasing in quantity or intensity (Ward, 72). While possible, there is no definitive data to support this hypothesis because these types of climatic events involve processes that are too specific to reproduce in climate models.

However, areas that are prone to these types of disasters already, like Southeast Asia, should be aware of the very real possibility of more extreme weather. Southeast Asia has a long history of natural disasters occurring including earthquakes, thunderstorms, flooding, and tsunamis. The most recent event effecting Southeast Asia was an earthquake that caused a tsunami that devastated Sumatra, and island in Indonesia; “the tsunami which struck north-western Sumatra on 26 December 2004 illustrated dramatically and tragically Indonesia's vulnerability to natural disasters” (“Indonesia”). Tsunamis are the results of earthquakes happening on the ocean floor. The energy released from one tectonic plate sliding underneath another one (convergent boundary) creates huge waves, called a tsunami, which is normally the effect seen on land as it crashes into beaches and coastlines. The tsunami wave that hit Sumatra in 2004 was as tall as 80 feet and killed nearly 300,000 people (“The December 26, 2004 Sumatran Tsunami”). The possibility of more tsunamis or worse tsunamis affecting this area is a very important element as the tragic results have been seen in the past.

While today, scientists are unable to predict whether or not a natural disaster will happen more, due to the changing climatic factors already seen today (most importantly the changes mentioned above about the sea surface), increase in natural disasters must be seen as possibility because the changing facts are the things that influence natural disasters. Sea surface temperatures, sea levels, and natural climate patterns are all aspects of the creation of a natural



disaster. Because scientist can track the changes in these characteristics, it's so important to remember that these changes intertwine and will cause other things to change—possibly influencing the rate and magnitude of natural disasters.

### Human Characteristics

While scientists have studied the global effects of our warming world, the most important element to focus on is how all of this will affect the people living on this planet. Who will be affected the most? How will developed nations be affected compared to developing nations? What will climate change do to those nations that are already struggling for food, water, and resources? Answers to such questions are difficult and sometimes unpleasant, as there are definite winners and losers in the future of the Earth. The winners are developed countries, and the losers are under developed, developing and poor countries (Mann, 190).

As assessed above, “tropical regions will likely suffer the most detrimental impacts” (Mann, 190) from global climate change. But, an important element to add to this equation is poverty; adding poverty increases these nation's vulnerability to climate change compared to nations that do not struggle with poverty. This can be seen in six different aspects: lack of technology and adequate infrastructure, increasing populations, smallholder agriculture, lack of medical resources, and these countries dependence on developed countries.

### Poverty

First, countries that are stricken with poverty do not have modern technology or infrastructure to sustain any amount of natural disasters. This has been seen very often, and usually very tragically, as several nations located near the equator have been devastated by

tropical storms. An example mentioned earlier of the 2006 tsunami in Indonesia gives evidence of the lack of structurally sound infrastructure. Much of this is due to large amounts of “squatter settlements” (also known as shanty towns or slums) located in urban areas of poor nations. A squatter settlement is defined as “a residential area in an urban locality inhabited by the very poor who have no access to tenured land of their own, and hence

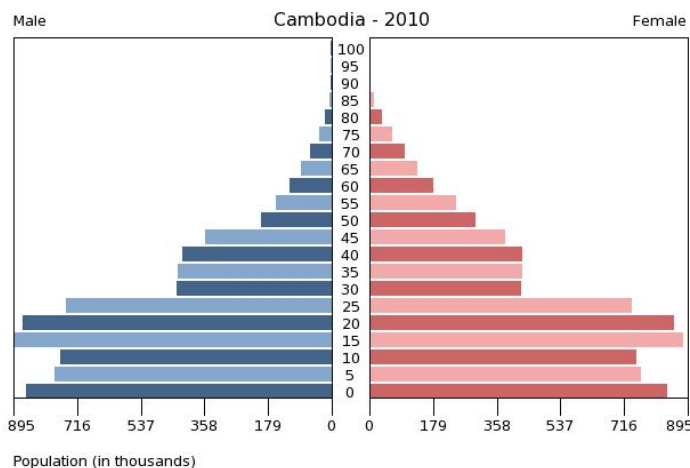


Figure 5: Population Pyramid for Cambodia, 2010

"squat" on vacant land, either private or public” (Srinivas). These houses are not built, but assembled by the family using it by means of cardboard, mud, straw, and any other materials that are available. Typically very small, these one-room houses have no foundation (their floor is the dirt ground), insulation, or ability to withstand strong weather events. They are normally crowded together to form very large areas (settlements) of similar structured houses. Physical infrastructure (roads, water supply, electricity, sewage...etc) is also very limited in these areas. “Water supply...to individual households may be absent, or a few public or community stand

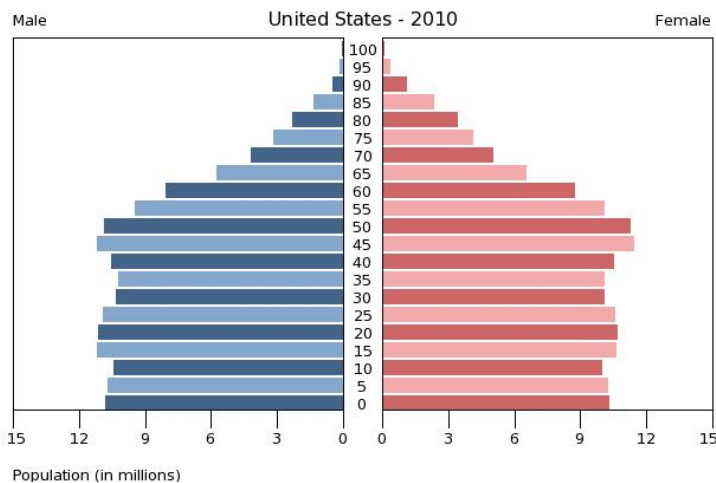


Figure 6: Population Pyramid for the United States, 2010

pipes may have been provided, using either the city networks, or a hand pump itself” (Srinivas). Many other problems arise in these types of living conditions including unsanitary conditions, crime, and disease.

Areas like squatter settlements are also formed due to another aspect of poverty:

increasing population. An increasing population is characterized by the amount of children born each year. In order for a population to be increasing, families would on average have more than two children and the majority of the population would be young (under

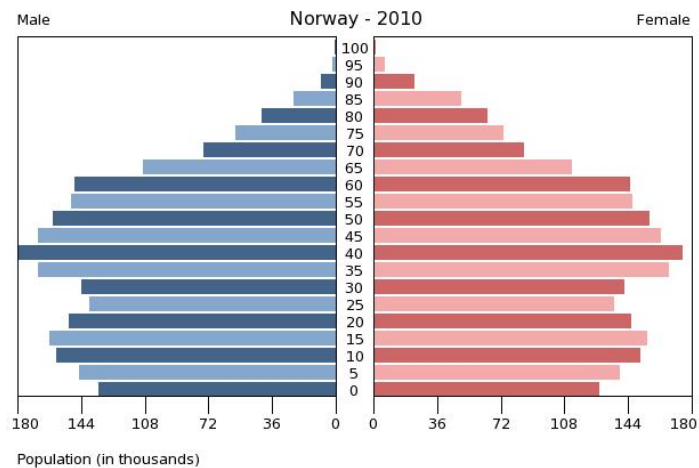


Figure 7: Population Pyramid for Norway, 2010

twenty years old). Seen in Figure 5, the shape of Cambodia's population pyramid (a visual display of the ages and sex of the overall population in a country) would be considered as growing/increasing because of the large number of people that are young. Comparatively, populations can also be classified as stable (meaning on average families have two children and there is no increase or decrease in population) and decreasing (meaning on average, families have less than two children, slowly shrinking the population size), seen in Figure 6 for the United States and Figure 7 for Norway, respectively. Especially for locations in Southeast Asia where land is very limited, growing populations cause overcrowding, underemployment, and poor health, all of these being aspects of poverty.

Another aspect of poverty that adds to countries' vulnerability is the amount of smallholding agriculture being practiced compared to large mechanized agriculture. Smallholding agriculture is used to describe "rural producers, predominantly in developing countries, who farm using mainly family labor and for whom the farm provides the principal source of income" (Morton, 19680). Many farmers in nations located close to the equator fall within this category. Because of the small amount of land and crops these farmers have, their

main objective in farming is to utilize the land to its fullest and minimize vulnerability to risks. Farmers plant several different types of crops every year in order to maximize their success rate. However, these farmers also lack modern farm equipment and technology like specialized irrigation, fertilizers, and pesticides. While they do everything they can to reduce vulnerability, they are not as successful as large-scale mechanized farmers because of their reliance on nature.

An example of how climate change could be very destructive to these farmers is by looking at increased precipitation that is likely to occur in Southeast Asia. Because of their lack of specialized and controlled irrigation, if rain was to increase it could cause crops to be over irrigated and damaged (Morton, 19682). Another example is if a new pest or crop disease were to occur due to change in climate—this could also be very harmful to these small-scale farmers. While over-irrigation and crop disease is a problem all farmers face (small-scale or large-scale), the difference lies in the fact that smallholding farmers don't have back-up incomes or resources if their crop fails. Subsidies are one of the biggest forms of government spending in the United States, constantly saving farmers from losing all their income when something goes wrong with their crop. Smallholding farmers do not have the luxury to rely on subsidies when something happens; they do not have any support from the government. If these farmers lose their crop, there is a large possibility that they would have to sell their farm in order to have money to buy food, or they could potentially also lose their lives.

Poor national healthcare is a big indicator on a countries poverty level. Not only does it show the abundance or lack of resources, but it also shows in a population's life expectancy. Looking at the nation's infant mortality rate tells the number of children that die before the age of 1 out of one thousand births. For Papua New Guinea in 2007, the infant mortality rate was 50, where in the United States in 2007 the infant mortality rate was 7 ("United Nations"). Similarly,

Papua New Guinea's under five years old child mortality rate (for every one thousand births) in 2007 was 65, when the United States under five years old child mortality rate was 8 ("United Nations"). Several factors are responsible for these statistics, but the most important one is the access to medical resources for the population. Some statistics on medical resources that are available to the public in Southeast Asia include the amount of medical staff, nurses, per patient ("Wanted: 2.4 million nurses"). Unlike the United States, where the average ratio of medical personal to patients is 2 to 1, due to the ability for medical staff to switch shifts every twelve or so hours, in most developing nations, the ratio can be 1 to 1, or even less ("Wanted: 2.4 million nurses, and that's just in India").

Many of these nations in Southeast Asia have endured struggles for freedom in the past from dictators and from invading nations. In the 1960s-1970s, the likelihood of communist type government was a very real possibility. Communism refers to a type of government in where social and economic classes within the population are abolished, and all that the nation owns and controls is under the ultimate control of the centralized government. These communist principals formalized by sociologist, Karl Marx, and many aspects of a communist society seen in the huge nation of the Soviet Union. Those western nations, including the United States, Great Britain, and France, not only believed communism was not the way a government should be run, but that a democratic society was necessary for every nation. Communism was almost a taboo word in the United States during this era. The Soviet Union was a large threat to the United States economically and militarily, and had long been an enemy of these democratic nations. An idea labeled the Domino Theory was believed by most leaders in the United States, which followed that if one nation in Asia were to fall under communism, then all other nations in Asia would follow the same pattern, like a row of domino's all falling down.

Vietnam is a prime example of how this country struggled between communism and democracy, and how the United States believed it was their responsibility to intervene. In the late 1960's, when the United States believed Vietnam was likely to support a pro-communist leader, they felt it was their responsibility to replace the leader with a pro-democracy leader. This idea led to a long a brutal war, splitting the country of Vietnam into North and South Vietnam and killing many people (American and Vietnamese). After the United States finally pulled out of the war in the mid 1970's, most of Vietnam and the surrounding nations had been horribly devastated environmentally, economically, and personally. Their weak state of being required Vietnam to rely on large nations like the United States, in order to start the rebuilding of their country. Due to this unstable and weak government only forty years ago, many of these nations are still feeling the effects today.

Many other developing nations are also in a very similar predicament as Vietnam as they continue to rely on large developed nations as their economic base. This can be seen in Indonesia and Cambodia as both have vast tropical rainforests full of trees that are available for harvest. Japan is one of the main importers of this area's hardwoods, as they take much pride in keeping most of their own forests intact. Other industries in Southeast Asia that rely on outside influence include fishing, mineral extraction, grain products, and even human labor as many previous Southeast Asian residents emigrate to large developed countries and generally are employed in low paid agricultural, maintenance, and cleaning occupations. While these jobs may seem undesirable to most wealthy Westerners, they are usually much more stable and better paid than jobs in Southeast Asia.

## Who's to Blame?

Before looking at the impacts of climate change on the population, it is important to first show the amount of human induced climate change that each area of the world has caused. A general trend can be seen as a nation becomes more modern. Looking at the United States for an example, when the Industrial Revolution began in England in the early 1800's, the United States wasn't too far behind. This country started to rapidly change its industries by the burning of fossil fuels (mainly coal and oil) to create heavy machinery for factories and agriculture, making work more efficient and more effect. The discovery of huge deposits of coal in the Appalachian Mountains region only helped the United States industrialize quicker. For over a century, the burning of fossil fuels was encouraged and increased and changed the way the world worked forever. The United States had become dependent on the energy fossil fuels delivered.

Although unknown at the time, the United States became one of the main nations responsible for the global warming phenomena experienced today. Now, knowing all we know about the effects of burning fossils fuels, the United States is trying to turn away from this type of resource and focus instead on renewable and natural resources; resources that are not harmful to the environment and are even helpful to sustaining the planet. This cycle of using fossils fuels to become more modern, reaching a certain height, and then cycling back to more natural ways of living is also seen in many countries in Western Europe as they have also begun to incorporate more natural and renewable resources. These nations (those that industrialized first) take most responsibility for the climate change observed today.

How about the rest of the world? Many of the nations that were not a part of the first industrialization period have started their own industrialization period in this century. They too can be seen going through the process of implementing more industry into their lives and jobs

and moving from the developing nations to the developed nations. This can be seen in the recent shift of global carbon emissions. In 2006, China replaced the United States as the number one carbon emitter in the world (“List of Countries by Carbon Dioxide Emissions”). While the United States still holds the number two spot, many developing nations have begun to introduce more modern technology to their industry in order to modernize their nation. While developed nations are most responsible for carbon dioxide emissions in the past, the developing countries will be more responsible for carbon dioxide emission in the future. This situation has potential to cause many problems as nations attempt to work together to lower global emissions.

An example of problems from this trend can be seen with the Kyoto Protocol, an international agreement that occurred during the United Nations Framework Convention on Climate Change in 1997 in Kyoto, Japan (“Kyoto Protocol”). If nations agreed to the Kyoto Protocol, they were agreeing to do what they could as a nation to bring their individual emissions down to 5% less than the 1990 emission totals in a five-year period (“Kyoto Protocol”). The Protocol places the heaviest burden and response on industrialized nations because “...developed countries are principally responsible for the current high levels of [greenhouse gas] emissions in the atmosphere as a result of more than 150 years of industrial activity” (“Kyoto Protocol”). Countries seen as developing nations had smaller reduction goals based on the argument that they aren’t as responsible for what has happened. While seeming like an encouraging start to emission reductions, problems arose as some nations argued that developing nations should take more responsibility in reducing emissions because they will be the leading greenhouse gas emitters in the future. Because of this argument, the United States and Australia have refused to agree to the Kyoto Protocol unless modified to give developing nations more responsibility. These two nations have been criticized by other nations for not taking responsibility for their



share of global emissions and for making excuses to delay the changes that need to be made. Whatever the cause may be, it is important to look at the facts. Although not number one anymore, the United States still stands at number two in global emissions, accounting for about 20% of total emissions (“List of Countries by Carbon Dioxide Emissions”). Seventeen countries out of the two hundred and twelve nations identified in the world are responsible for 93.3% of all global greenhouse gas emissions (“List of Countries by Carbon Dioxide Emissions”). That leaves one hundred and ninety-five nations contributing only 6.7% of all emissions. Looking even further to the Region of Southeast Asia, “small island states account for less than 1% of global greenhouse gas emissions” (Ebi, 1).

Although one could continue playing the “blame game” and putting full responsibility to certain nations, the important thing to remember is that human lives are at stake for the type of lifestyle many humans live today. The United States will also see problems as the climate gets warmer—they are not completely immune to effect of climate change. However, because of their economic and political standing, it will be able to change in order to survive the changes. But the real question to ask is, if countries in Southeast Asia will be able to do the same? Will they also be able to adapt and change with the coming effects? Will they as a nation be able to rise above and work together to achieve their goal? This answer cannot be as easily answered.

Climate change is a global problem—every country and every person will be affected in some way from the changing climate (if not already). Problems will arise and solutions will follow. Some places are more vulnerable to drastic changes than other locations, and some people are more prepared than other people for these changes. The only thing that can be held as certain is that things will change. By analyzing an area’s vulnerability to global climate change, it helps give a more global perspective on this topic.

## Conclusion

As assessed in this report, global climate change is upon the world at this very moment. The evidence to support a human induced global warming pattern is strong and the data analyzed and assessed for the future is extensive. Many changes will come to a warming world, and every part of the world will feel these effects in different ways and amounts. Vulnerability to climate change is not equal everywhere, some areas will experience more negative effects from climate change than others. Further, poorer or developing nations will be much more vulnerable than wealthy or developed nations. When looking at the region of Southeast Asia (still considered a developing nation), the data shows that the main climatic concerns for this area include rising sea levels, warming sea surface temperatures, changes in local weather patterns, and increase in amount and degree of natural disasters. Some of the possible effects from these changes include losing land or entire island nations as coastlines disappear, more precipitation causing floods and damage to crops, increasing or decreasing the effect of ENSO which could cause possible increased precipitation or drought, and because of warmer temperatures and more available water, the possibility of fiercer and more abundant natural disasters in this area. Another aspect that is important in this area that affects vulnerability of this region is the amount of poverty that is present in these nations. Poverty is measured by many aspects and by looking at the lack of technology and adequate infrastructure in the area, the rapidly increasing populations of these nations, the amount of smallholder agriculture farmers, the lack of medical resources, the lack of organization in governments to respond to crisis, and these countries dependence on developed countries, the vulnerability continues to increase. However, most of these changes in global climate change are not the product of this area's decisions - these changes are mostly due to the

amount of greenhouse gases added to the atmosphere by developed and modern nations like the United States and most of Western Europe. The idea of social justice is important to remember: because the United States and Western Europe are proven more responsible for the global climate warming, they should carry the weight of the responsibility by making the most drastic changes for the future. However, this does not always play out as one would wish, seen in the United States refusal to sign the Kyoto Protocol.

Overall, the most important aspect of this study is to equip regions and countries with adequate information to best prepare for what is to come in order to save the lives of humans. Preparation and action is what will define winners and losers among the developing nations. In the region of Southeast Asia, the many climatic aspects classifies this region as highly vulnerable to climate change. A very important element to this equation is the demographics of the region and the amount of poverty that is present. These factors will only bring upon negative increases of consequences. While the reality of these climatic changes can be tested and predicted, what cannot be predicted are the responses these nations take to avoid these possible consequences. Not only is local action important for this region, but action from the entire world to help ease the pain from climate change. Individual, economic, political, and global actions are all necessary.

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