Climate Change in the Republic of the Marshall Islands

Pacific Islands Climate Education Partnership

You may have heard the term **climate change**. What does this term mean? In what ways is the climate changing? How does climate change affect the Republic of the Marshall Islands? The purpose of this booklet is to answer these questions.

What are weather and climate?

To learn about climate change we need to understand the difference between weather and climate. **Weather** is the short-term condition of the atmosphere in a specific place, such as where you live. Is it raining today? Where is the wind blowing from and how strong is it blowing? Is the air hot or cool? How cloudy is the sky?

Climate is the long-term average weather pattern in a specific place or region. When scientists describe the climate in a place, they use measurements and observations of the weather that have been made over periods of decades or even longer. The climate in a place has very big effects on the plants, animals and people who live there

The Marshall Islands has a climate where the weather changes over the course of a year from a wetter season to a drier season (**Figure 1**). Among most islands in the northern hemisphere Pacific Ocean, the more northward the island, the longer and drier the drier season tends to be. Other places on our planet have climates where the weather changes a lot over the course of a year. For example, many places have very cold snowy winters, and very hot summers.

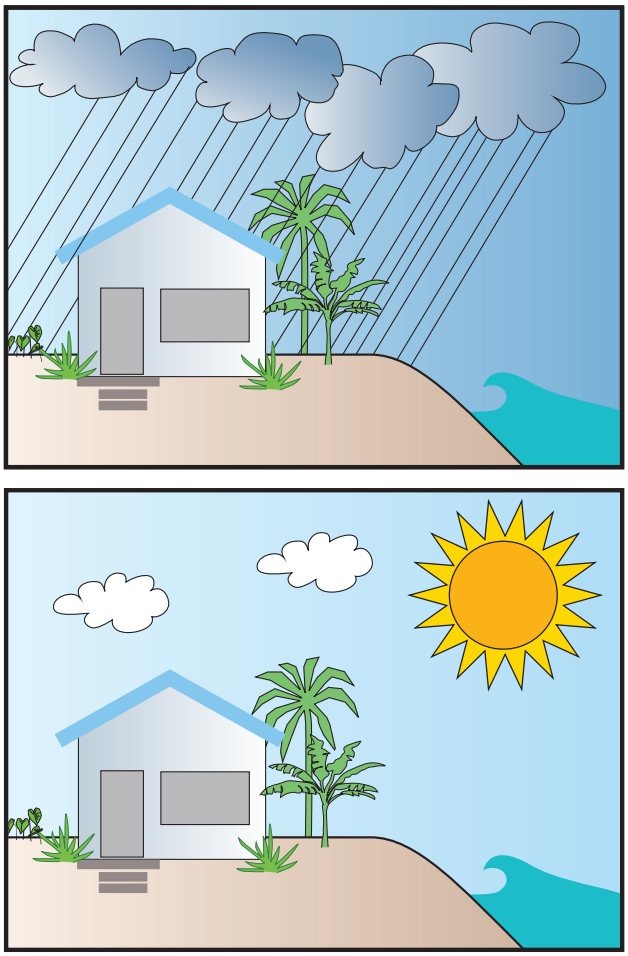

Figure 1 *In the Marshall Islands, the weather changes from a wetter season (May to November) to a drier season (December to April).*

Climate describes what kind of weather you can expect to happen. Weather describes what is actually happening. If you visit a place in the wet season, you should expect that it will be rainy. However, the days that you visit, the weather could actually be dry. It was probably rainy before you visited, and it will probably become rainy again after you leave.

What is the climate in the Marshall Islands?

Warm and Humid

The climate in the Marshall Islands is generally warm and breezy with lots of water vapor in the air (this is known as high **humidity**). The map (**Figure 2**) shows two factors that play the biggest roles in causing this climate:

- The Republic of the Marshall Islands (RMI) is located near the equator
- RMI is surrounded by the ocean in all directions

Places near the equator get a lot more energy from the Sun than places that are farther away from the equator. This location is the main reason that the Marshall Islands are warm. Warm ocean water heats the air above it and also puts a lot of water vapor into that air. The warm ocean around the Marshall Islands helps keep the temperature warm at night, and makes the air warm and humid.

Figure 2 *The Marshall Islands (RMI) are located in the western Pacific Ocean near the equator.*

High Islands and Low Islands

There are two main kinds of islands in the Pacific Ocean: high islands and low islands. Communities of people on both kinds of islands have homes, grow food, go fishing, and drink fresh water. The fresh water that they have comes from the rain that falls on their island.

Figure 3 shows the two different kinds of rain that fall on Pacific islands. One kind of rain happens everywhere: over the open ocean, on low islands, and on high islands. This kind of rain happens because the air has so much water vapor in it that the water vapor condenses, forms clouds, and then precipitates. This is called **convective rain**.

A second type of rain is caused by high islands. When warm humid air is forced to rise up the slopes of a high island the cool air it encounters causes the water vapor to condense, making clouds and rain. This is called **orographic rain**.

High islands usually get more rain than low islands. For instance, on the low island of Majuro in the Republic of the Marshall Islands, rainfall averages 132 inches a year. On the high island of Kosrae in the Federated States of Micronesia, the annual rainfall averages 300 inches in the mountains and 200 inches on the coast.

The fact that Kosrae's mountains get more rain than its coasts provides the clue why high islands get more rain than low islands. The air is much colder near the top of a high mountain compared with the bottom of that mountain. When warm, humid air blowing in from the ocean hits a mountain, that air is forced upward into the colder mountain areas. When warm humid air becomes colder, its water vapor condenses from the gas state into the liquid state, and forms water droplets. These water droplets become clouds that then can rain on the island.

All of the islands in RMI are low islands. Low islands are usually made of coral sand and gravel. Low islands do not cause humid air to condense because they do not extend into the cold air at high elevations. The main source of fresh water on a low island comes from rainstorms that move across the ocean and happen to run over the island.

Two Types of Rain on Pacific Islands

Everywhere (convective)

Air has so much water vapor that clouds form, and rain falls on the open ocean and on any low or high islands that the clouds blow over.

Caused by Mountains (orographic)

Warm humid air becomes colder when it rises up the slopes of a high island mountain. Cooled water vapor condenses and falls as rain on the high island.

Figure 3 *The fresh water on Pacific islands comes from two types of rain.*

Wetter and Drier Seasons with Variable Rainfall from year to year

The weather and climate in the Marshall Islands (**Figure 4**) have been observed and analyzed for centuries, and have been scientifically measured for decades. There are several predictable patterns in addition to being generally warm and humid. One of the most important climate patterns is that there is a wetter season and a drier season.

The hot and humid rainy season extends from May through November. The drier season is usually between December and April when the average monthly rainfall is much less. Most Pacific Islands near the equator also have wetter and drier seasons.

The amount of rainfall in RMI can be very different between northern and southern islands. Atolls at 10°N and further north, such as Enewetak, usually receive less than 50 inches (127 centimeters) of rain in a year and are very dry in the dry season. Atolls 7°N and further south, such as Majuro, generally receive more than 100 inches (254 centimeters) of rain in a year.

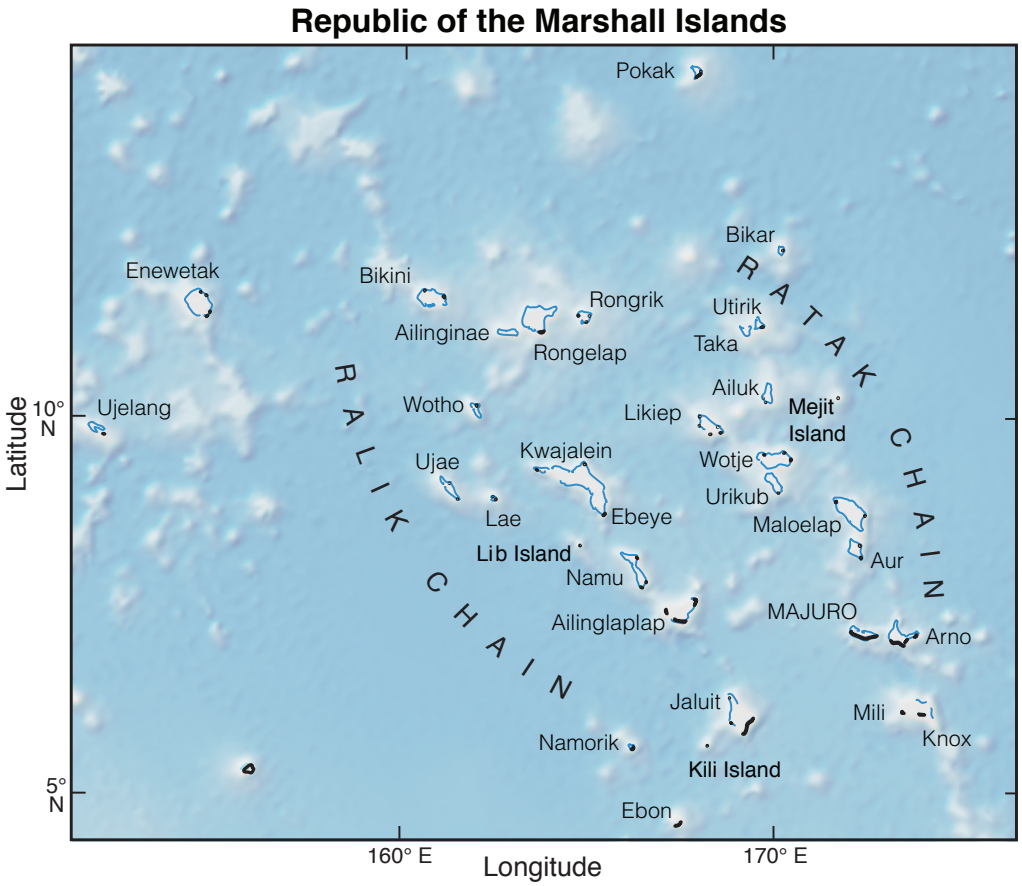

Figure 4 *RMI is mostly located at latitudes between 5°North and 12°North. Atolls at 10°N and further north generally receive less rain, especially in the dry season.*

Figure 5 shows the annual rainfall measured in Majuro between the years 1955 and 2010. Note that the amount of rain changes a lot from year to year. Some years had 150 inches (381 centimeters) or more of rain, while other years had 90 inches (229 centimeters) or less of rain.

This kind of change in rainfall from year to year is a natural feature of the climate in many Pacific islands that are near the equator. Scientists say that the amount of rainfall has a lot of **variability** (natural change from year to year).

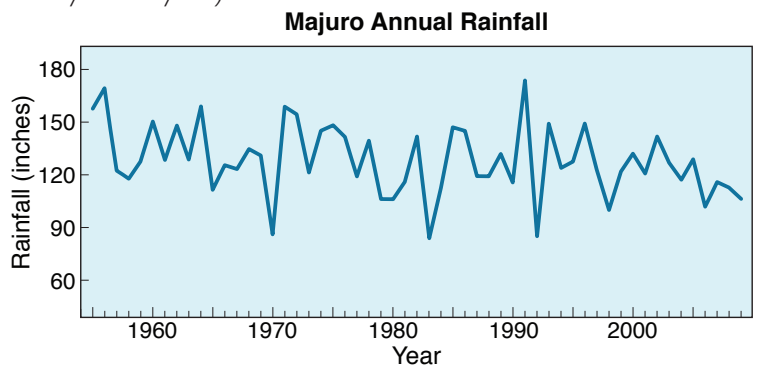

Figure 5 *The amount of rainfall in Majuro has a lot of variability from one year to the next.*

Regional Wind and Rain Patterns: The ITCZ and El Niño

Near the equator, the winds from the northern hemisphere and in the southern hemisphere come together and cause a band of rain called the **Intertropical Convergence Zone** or ITCZ. This very cloudy and rainy area can be seen in satellite photos (**Figure 6**) as a band of thunderstorm clouds somewhat north of the equator.

The Intertropical Convergence Zone is a band of clouds near the equator

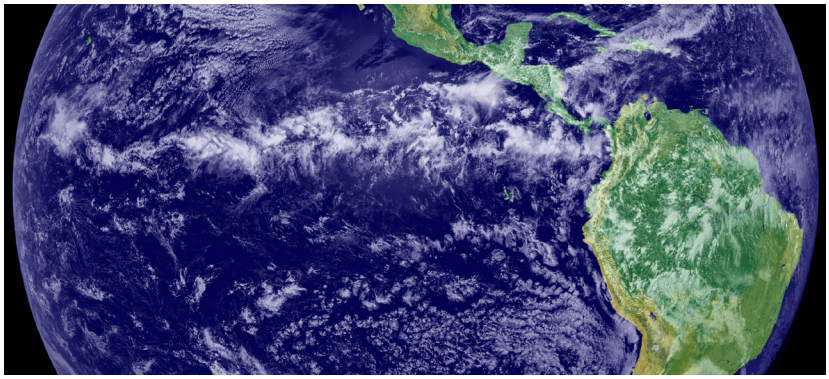

Figure 6 *The strong sun and warm water of the equator heats the air and increases its humidity. The warm humid air rises and becomes colder as it gets higher in the atmosphere. As the rising air gets colder, the water vapor condenses and forms big clouds that release the water in thunderstorms.*

This long band of rainy area near the equator does not just stay in one place. The wetter season occurs in the summer when the area of rain tends to move to the north, bringing it closer to the RMI. The drier season occurs when the area of rain moves further south away from most of the islands in the RMI.

In the RMI winds mostly blow from the northeast throughout the year. These winds are called **trade winds**. But there is a second type of wind, called a **monsoon wind**, that sometimes blows from the west. Trade winds tend to be most frequent from December through March, and monsoon winds may occur from June through September.

The east to west trade winds play a large role in the climate of the equatorial Pacific Ocean. These winds can change during a climate pattern that is called the **El Niño Southern Oscillation** (ENSO). When trade winds are weaker than usual, and monsoon winds are dominant scientists say that it is an **El Niño** year. When the trade winds are stronger than normal, scientists call it a **La Niña** year.

When the winds are normal it is called a **neutral** year. **Table 1** summarizes the differences between El Niño years, La Niña years, and neutral years.

In a neutral year (normal winds), the waters in RMI are much warmer than waters in the central or eastern portions of the Pacific Ocean. The warm water leads to strong evaporation and there is abundant rain.

In a La Niña year, strong trade winds blow across the ocean surface into Micronesia. This raises the level of the ocean and can cause **coastal erosion** (land loss due to wave action) and damaging **king tides** (the highest tides of the year). La Niña years also tend to be rainy in the Marshall Islands.

In an El Niño year, trade winds are weaker than normal (or absent). An El Niño year is usually drier and there is a greater chance of **drought** (an extended period of little rain). In addition, warm ocean water moves away from the Marshall Islands toward the central and eastern Pacific Ocean, and causes sea levels in RMI to decrease.

Table 1 ENSO Conditions and the Effects of ENSO Changes

Feature	Neutral ENSO Year	El Niño ENSO Year	La Niña ENSO Year
Wind	Normal east to west winds	Weaker east to west winds; can even blow from west to east	Stronger east to west winds
Rainfall	Usual amounts of rainfall with normal variability	Following an El Niño, the Marshall Islands tend to be drier than usual, and can have long droughts	Marshall Islands tend to be wetter than usual
Sea Level	Usual sea level with normal tide variability	Lower sea levels so that high tides tend to cause less flooding	Higher sea levels so that high tides tend to cause more flooding

Table 1 *lists the differences between neutral years, El Niño years, and La Niña years.*

Extreme Weather Events

Extreme weather events are another important climate feature. An extreme weather event is the kind of weather that can cause a lot of damage and problems for ecosystems and people. The main extreme weather events that happen in the Marshall Islands are droughts and big storms.

Droughts typically occur in the months of January to June, especially in the year following an El Niño. During particularly strong El Niño drought, the rainfall can decrease by as much as 80%. A severe drought in the northern Marshalls occurred in the winter and spring of 2013 and returned again in 2014. However, scientists predict that in the future, droughts in RMI will

happen less often and extreme rain events will happen more often. Scientists also predict that the overall amount of rainfall in the RMI will increase in the future[1].

Very strong storms in the equatorial Pacific Ocean region are called **tropical cyclones**. These storms typically happen between September and November. Fortunately, these storms are usually weak when they pass through the Marshall Islands, but are more intense in El Niño years because of warmer sea surface temperatures.

Table 2 lists the main features of the climate in the Marshall Islands.

Table 2 Main Climate Features

We can now list the main features of the climate in the Marshall Islands:

- Warm and humid days and nights all year
- Wet and dry seasons, with northern islands getting less rain
- Lots of variability in annual amounts of rain
- Breezy with winds normally blowing east to west
- Lots of variability in wind speed and wind direction
- Extreme weather events: drought, tropical storms and cyclones
- Strong influence by climate conditions known as El Niño, La Niña and the position of the Intertropical Convergence Zone

Table 2 *lists the main features of the climate in the Marshall Islands.*

What is happening to climate on our planet?

Our planet has been around for a very long time (more than four billion years). During that time the climate of the planet has changed many times. Sometimes the climate has been very cold, with large amounts of ice covering most of the land and even large parts of the ocean. Sometimes the climate has been very warm when even the polar regions had little or no ice.

For the past 10,000 years, Earth's climate has been very comfortable for people and for ecosystems. However now, the climate is beginning to change because of human activities, especially our burning of fossil fuels (oil, coal and natural gas, which are made of fossil plankton and plants). Since our human activities are causing the global climate to become warmer, this change is often called **global warming**.

1 Pacific Climate Change Science Program, Australian Government, 2014. Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports, www.pacificclimatechangescience.org

We use oil to make the fuel that provides the power for transportation (such as gasoline for cars, boats and trucks). People also burn fossil fuels to make electricity. When we burn oil and coal, the burning produces gases (especially carbon dioxide) that trap heat in the atmosphere. Other human activities are also producing gases that go into the atmosphere and trap heat (**Figure 7**). This trapping of heat in the atmosphere is causing Earth's climate to get warmer.

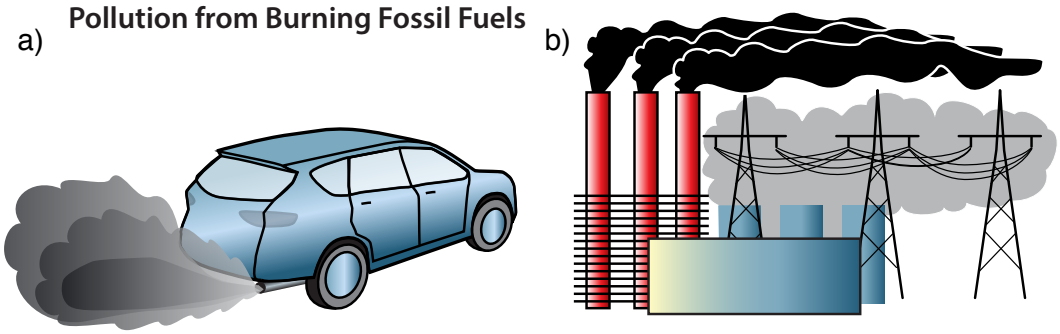

Figure 7 *When we burn fossil fuels (oil, coal and natural gas), they produce gases that stay in the atmosphere and trap heat, causing global warming. a) Oil is used to make gasoline to run cars and trucks. b) Oil, coal and natural gas are burned to make electricity.*

The graph of average global temperature over the past century shows that the global temperature has been increasing (**Figure 8**). The temperature data are collected from weather stations around the world. There is a lot of variability from year to year. However, over all the years in the graph, there is a clear trend that Earth's climate has been getting warmer. Global temperatures in the last ten years are significantly higher than they have been for any other ten-year period.

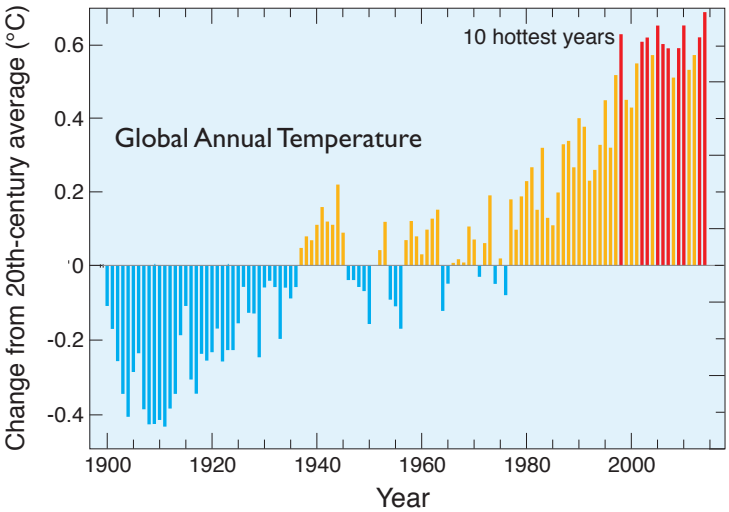

Figure 8 *The annual average temperature of the air close to Earth's surface.*

Over the past 100 years, Earth's temperature has increased about 1.6°F (0.9°C). While this amount may not seem very much to us, it is actually a lot for planet Earth. A decrease in global temperature of about 10°F (5.6°C) can cause an ice age. In the geologic past when Earth's average temperature was 10°F higher, most of Earth's ice was gone and sea levels were 100 feet (30 meters) higher.

The higher global temperatures cause many other changes to weather patterns and conditions on the planet. As a result, scientists tend to use the broader term climate change to describe this issue, rather than global warming. These climate changes include:

- Glaciers everywhere in the world are melting.
- Sea level is rising.
- The oceans are getting warmer.
- Ecosystems are moving away from current locations toward locations that are not as hot.
- Warm seasons are starting earlier and lasting longer.
- More of the planet is having tropical climate.
- Generally wet places are getting wetter (flooding) and dry places are getting dryer (drought).

These and many other observations show that Earth's climate system is rapidly changing because of global warming. Climate change affects the Marshall Islands in many ways. The rest of this booklet focuses on the changes that are already happening and the climate changes that are predicted to happen. We will also discuss what people in the Marshall Islands can do to help protect themselves from the impacts (damaging effects) of climate change.

What impacts of climate change are happening in the Marshall Islands?

As shown in **Figure 9**, the four most important impacts (damages) of global climate change on the Marshall Islands are:

- Higher air and ocean temperatures
- Changing rain patterns
- Sea level rise
- Ocean acidification

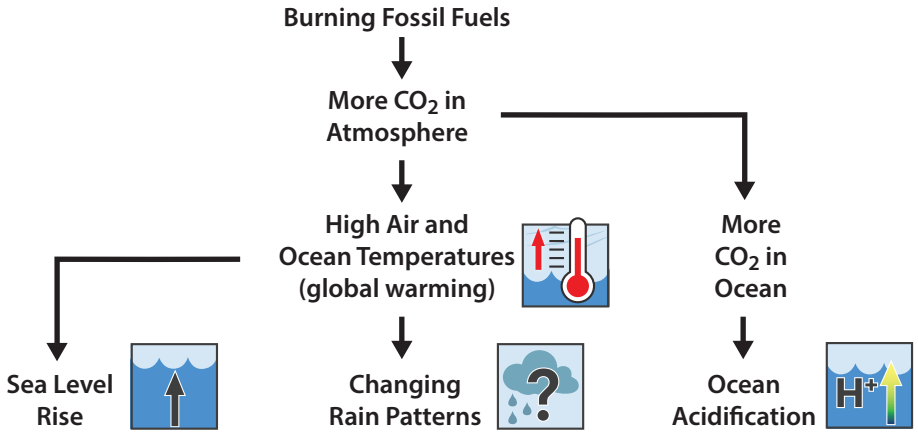

Figure 9 *Human activities, mainly burning fossil fuels, are putting more heat-trapping gases, especially carbon dioxide, into the atmosphere. These activities are causing global warming. The four major impacts of climate change in the Marshall Islands are shown with a graphic image next to each one.*

Global warming means that **air and ocean temperatures are warmer**. These higher temperatures can directly harm ecosystems and human communities. For instance, warmer ocean water is an unhealthy condition for coral reefs and fish. In addition, these higher temperatures are causing one of the most serious climate impacts: **sea-level rise**.

Higher ocean temperatures cause the oceans to have a larger volume.[2] Thus, the ocean surface rises. This accounts for about 1/3 of the amount of global sea level rise. Higher air temperatures also cause mountain glaciers to melt, and this water flows into the ocean (accounting for another 1/3 of global sea level rise). The last 1/3 of global sea level rise comes from melting ice on Greenland and Antarctica. As a result of warming seawater and melting ice, oceans have a higher volume, and sea levels around the world are rising.

Rising sea level causes coastal erosion and flooding by waves and high tides. During heavy rain storms it can prevent the rain from draining into the sea, causing more flooding. This sea level rise is one of the most damaging impacts of climate change, especially for island communities.

Global warming also causes changes to rain patterns. For the Marshall Islands, average rainfall is expected to increase, especially in the wet season, along with more extreme rain events. Droughts are expected to decline in frequency.

Ocean acidification is another major impact caused by higher carbon dioxide levels. When carbon dioxide dissolves in the ocean, it forms a weak acid. As excess carbon dioxide in the atmosphere dissolves in the ocean, it changes the acid-base chemistry of the ocean, and causes it to become more acidic. Ocean acidification is included as a climate change impact because it is caused by the same increase in carbon dioxide that causes the other climate change impacts. Ocean acidification also harms many of the same marine ecosystems, especially coral reefs, plankton, and shellfish that are additionally harmed by higher ocean temperatures.

How do these climate change impacts harm ecosystems and human systems in the Marshall Islands?

Many people think that humans should protect the natural world. All four of the climate change impacts shown in Figure 9 (sea level rise, higher temperatures, drought, and ocean acidification) harm Marshall Island ecosystems. These impacts harm the organisms that live there and the human communities that get many benefits from these ecosystems. These benefits include cultural and spiritual values, food, and income from fishing and tourism (**Figure 10**).

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[2] When something gets warmer, it expands (gets larger) in size. This increase in size happens with solids, liquids, and gases.

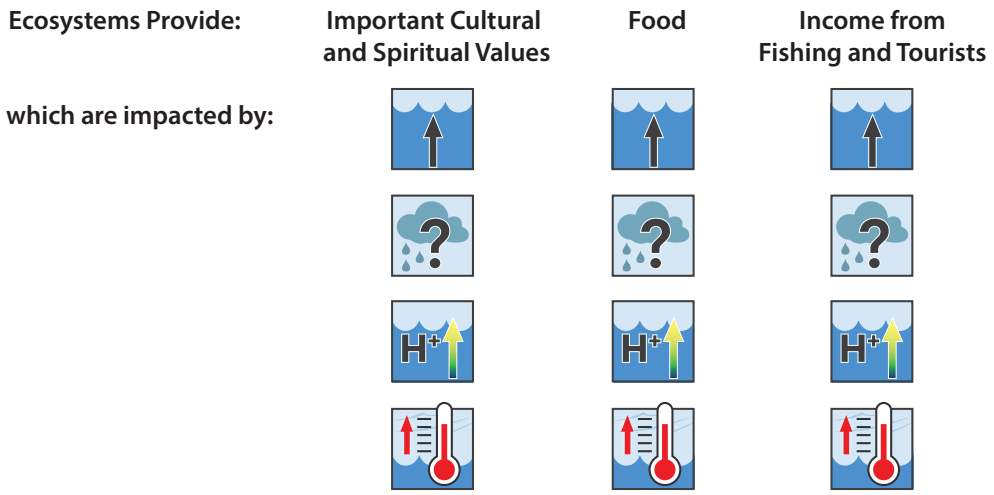

Figure 10 *Sea level rise, changing rain patterns, ocean acidification and higher temperatures all damage major services that are provided by ecosystems.*

In addition, climate changes harm the human systems that people depend upon for their homes, food, fresh water, and transportation (**Figure 11**).

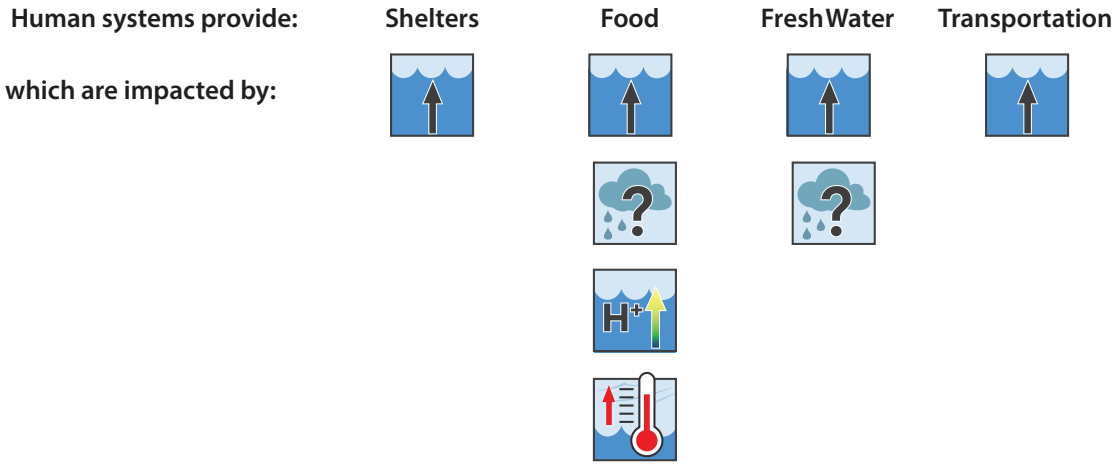

Figure 11 *Climate change damages major services that are provided by human systems.*

Sea level rise is especially important since it harms essentially all Marshall Island ecosystems and human systems (**Figure 12**). Since 1993, sea level rise has been occurring around the Marshalls at about 0.3 inches per year. Sea level rise causes beach erosion, flooding during high tide, and increased storm surge. Sea level is expected to continue rising, perhaps by more than 3 feet (1 meter) by the year 2100.

This increase in sea level means that anything that makes the ocean waves reach farther inland (such as a king tide or a tropical cyclone) will cause more flooding than when the sea level was lower. For example, in January of 2011 serious flooding occurred without any strong winds or high waves. In that case it was the highest tide of the year happening with higher sea levels because of climate change and also because it was a La Niña year.

Higher sea level also causes more erosion of the coasts. Higher sea level also affects the availability of food and water. When the ocean floods the land, the soil becomes salty, which damages the natural plants and trees, and also makes it much harder to grow food. The higher sea level can also reduce the amount and quality of the underground fresh water.

Figure 12 *During the highest tide period of the year in late January 2011, ocean water washed across the road and into houses in parts of Majuro Atoll.*

Often the different impacts of climate change harm the same ecosystem or human system, and cause more damage than either would by itself. For example, higher ocean temperatures and ocean acidification both harm local marine ecosystems such as coral reefs (**Figure 13**). Coral are very sensitive to increases in temperature. Since the 1970's the Pacific Ocean has warmed about 0.7°F (0.4°C). Warmer ocean water can lead to coral bleaching, and damage to local marine ecosystems and fishing.

The outside hard parts of many shelled organisms, such as plankton, and coral are made of carbon combined with calcium and oxygen in a solid form called calcium carbonate. As the ocean becomes more acidic, it is much more difficult for many marine organisms to make and keep their hard calcium carbonate shells. Since plankton and coral are very important for marine ecosystems, this ocean acidification also can decrease the populations of many marine organisms that do not have shells. One quarter of all sea animals spend time in coral reef environments during their life cycle.

Figure 13 *Ocean acidification harms the coral, plankton, and other organisms that use calcium carbonate to make their shells and the reef. Coral reefs are also damaged by higher ocean temperatures.*

How can Marshall Island communities adapt to the impacts of climate change?

We use the term **climate adaptation** to describe the things that people, communities and governments can do to help protect themselves from harmful climate impacts. A Pacific Island community that has planned and implemented climate adaptation strategies for their ecosystems, food supplies, homes, roads, and water supplies will suffer less damage and recover more quickly from climate change impacts.

Plants and animals living in Pacific Island ecosystems are adapted to the current conditions, such as temperatures and rainfall patterns. Since temperatures normally do not change very much over the course of a year, many local plants and animals have never experienced the higher temperatures that may be happening already and that are predicted to happen even more in the future. Changes in sea level (**Figure 14**) and rainfall, higher temperatures, salt from ocean flooding, and a more acidic ocean all can cause very significant damage to land and marine ecosystems.

In addition to the stress from climate change impacts, these ecosystems are often already being harmed by other human actions. Activities such as polluting land or water, cutting down too many trees, catching too many fish, disturbing reefs, and replacing natural environments with industrial development all harm local ecosystems.

Ecosystems that are close to their natural condition are more **resilient** with respect to climate change. This means that they are damaged less by climate changes and can recover faster than ecosystems that are harmed by other human activities. The best climate adaptations for ecosystems are activities that help the ecosystems return to and keep their natural conditions. These activities include preventing and removing pollution, and carefully managing human interactions with the ecosystem such as fishing, cutting trees, and tourism.

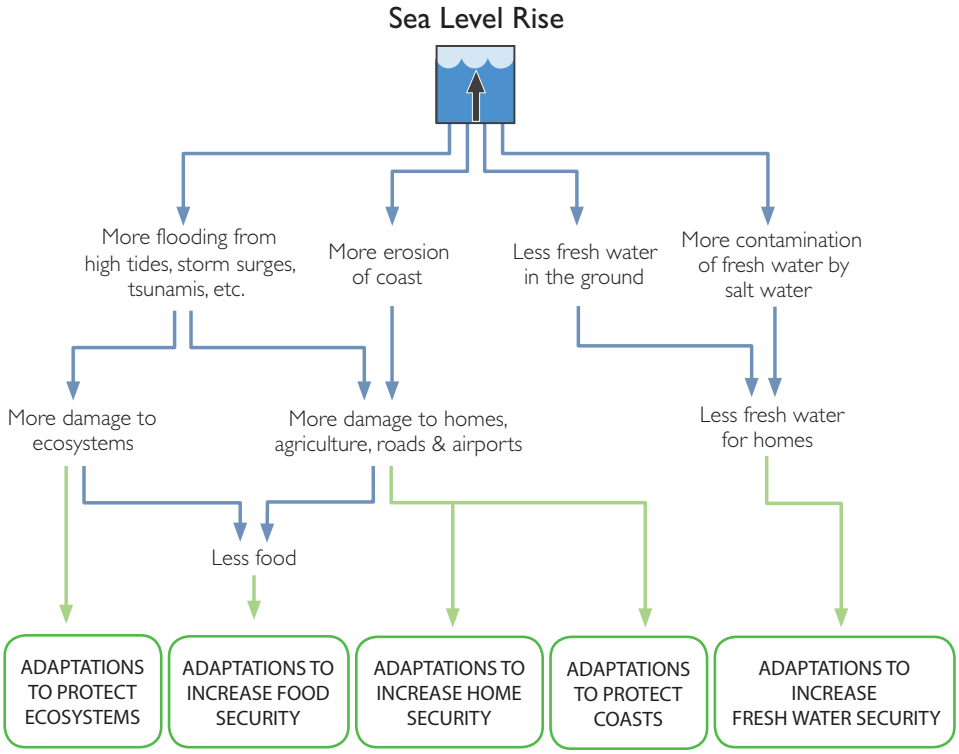

Figure 14 *Impacts of sea level rise and kinds of adaptation strategies.*

Because ecosystems provide so many important benefits to island communities, these ecosystem adaptations also increase the resilience of human systems. In addition, human systems (such as homes, getting freshwater, getting food, and transportation) require other

adaptation actions. These adaptation actions generally make the human systems more flexible, efficient and sustainable. In other words, these climate adaptations for human systems:

- Give the communities more ways to meet their needs (they are flexible),
- Do so in ways that provide the maximum benefits for the cost (they are efficient), and
- Rely more on island resources than on outside resources (they are sustainable).

Unfortunately, people living on low islands such as the Marshall Islands, have fewer choices and resources to reduce the impacts of climate change than do people who live on high islands or continents. Atolls lack the higher elevations that can provide much more security with respect to avoiding flooding, getting fresh water, growing food, and building roads. If the impacts of climate change continue to increase, the Marshall Island atolls and way of life will become increasingly threatened.

The Micronesia Conservation Trust has produced materials that help Pacific Island communities understand climate impacts. These materials provide guidance with respect to planning and implementing climate adaptation activities. Under the title *Adapting to a Changing Climate*, these materials include large flipcharts that can be brought to local communities and a booklet that summarizes and explains the information in the large charts.[3]

In general, there are three kinds of climate adaptation activities that can help make people, communities, and nations safer with respect to rising sea levels and other climate impacts. These kinds of adaptation activities are:

- Protecting local ecosystems to help these ecosystems be more resilient
- Increasing the resiliency of the communities' physical systems such as homes, roads, water supplies, and food supplies
- Making the community's cultural systems stronger and healthier so people in the community effectively plan and implement climate adaptation strategies that work for that community

These climate adaptations can help make life on the Marshall Islands safer and more comfortable for more years into the future.

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[3] The booklet *Adapting to a Changing Climate* can be accessed at http://www.cakex.org/virtual-library/3439

Glossary

Air and ocean temperatures are warmer A direct effect of global warming is that the air gets warmer. Because the air and the ocean touch each other and are mixed together by winds and waves, heat can travel out of the air and into the water making the ocean warmer. Warmer temperatures in the air and ocean cause many changes to the worlds ecosystems, weather, climate, and human communities.

Climate The long-term pattern of weather in a particular area. Climate is measured by assessing the patterns of variation in temperature, humidity, atmospheric pressure, wind, precipitation, and other properties of the weather in a given region over long periods of time.

Climate adaptation Actions taken by people, communities and governments that help protect themselves, and ecosystems, from harmful climate impacts.

Climate change A change in global or regional climate patterns. In particular a change apparent from the mid to late 19th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

Coastal erosion Wearing away and loss of beaches and land due to waves. Coastal erosion gets worse when sea level rises.

Convective rain Convection of the air occurs when hot air moves upward. This develops when Earths surface becomes heated more than its surroundings leading to strong evaporation that makes clouds. The clouds produce convective rain that falls as showers with rapidly changing intensity. Convective rain falls over a certain area for a relatively short time, because convective clouds have limited horizontal extent. Most precipitation in the tropics appears to be convective.

Drought An extended period of little rainfall.

El Niño A natural climate event, lasting typically less than 1 year, which occurs in the Pacific when the normal trade winds weaken (or die) and are replaced by monsoon winds. This causes warm water in the western tropical Pacific to surge into the central and eastern Pacific. El Niño can cause temporary global changes in the climate and weather.

El Niño Southern Oscillation (ENSO) Refers to a Pacific climate event that has two states: El Niño and La Niña. These states govern the movement of a large body of warm water to the eastern (El Niño) or western (La Niña) regions of the tropical Pacific Ocean. ENSO states cause strong climate and weather changes around the globe.

Global warming When the air in the lowest portion of the atmosphere (the troposphere) gets significantly warmer than normal. Global warming is caused by an increase in the amount of heat-trapping greenhouse gases when humans burn fossil fuels (coal, petroleum, natural gas) for energy. Other types of greenhouse gases produced by humans also contribute to the problem.

Humidity The amount of water vapor in the air.

Intertropical Convergence Zone (ITCZ) Known by sailors as "the doldrums", the ITCZ is a belt of low air pressure which circles Earth generally near the equator where the trade winds of the northern and southern hemispheres come together. The ITCZ tends to be a region of thunderstorms and high rainfall.

King tide A term that describes an unusually high tide, usually the highest tides of the year. King tides may cause flooding on low-lying coastal lands.

La Niña A natural climate event, lasting typically less than 1 year, which occurs in the Pacific when the trade winds grow stronger than normal. This causes a body of warm water to accumulate in the western tropical Pacific and is an opposite state to El Niño.

Monsoon winds Winds that blow from the west and typically bring a change in weather conditions.

Neutral A year in which ENSO conditions are neither in the El Niño or La Niña states.

Ocean acidification Decrease in the pH of Earth's oceans, caused by the uptake of carbon dioxide (CO_2) from the atmosphere. An estimated 30–40% of the carbon dioxide released by humans into the atmosphere dissolves into oceans, rivers and lakes, lowering their pH.

Orographic rain Orographic rain occurs when humid air is forced upwards over rising terrain, such as a mountain, into colder air at higher elevations. This causes the rate of condensation to exceed the rate of evaporation, producing orographic clouds that yield orographic rain.

Resilient communities are better able to bounce back from disasters and disruptions, such as tropical cyclones, in a sustainable way and maintain a good quality of life for all. They are better prepared for uncertainties and able to adapt to changing conditions.

Sea level rise When the average level of the surface of the ocean rises, especially as a result of global warming that melts glaciers (increasing the amount of water in the ocean) and warms the ocean (causing ocean water to expand, upwards).

Trade winds A wind blowing steadily toward the equator from the northeast in the northern hemisphere or the southeast in the southern hemisphere, especially at sea.

Tropical cyclone A rotating system of strong winds, clouds and thunderstorms that produce heavy rain. Tropical cyclones are organized around a center, or eye, where there is low air pressure. Tropical cyclones cause storm surge and are responsible for severe damage where they make landfall in human communities.

Variability Meaning that the state of the weather, or climate, has a high degree of change. Climate conditions that are variable are always changing.

Weather The state of the atmosphere at a place and time as regards heat, dryness, sunshine, wind, rain, and other conditions.

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Illustrations by Nancy Hulbirt, Anita Moorjani, and Jennifer Mendenhall.

Photographs

Figure 3. Photograph of rain
http://1.bp.blogspot.com/-Db5Kw3IPBtc/TnusYWYDK2I/AAAAAAAADQU/UCVHft016iQ/s1600/7milebeach.jpg
Photograph of mountain
http://www.nbnweathershots.com.au/sites/default/files/20120410%20Bora%20Bora%2884%29.JPG"

Figure 6. Photograph of Intertropical Convergence Zone (ITCZ)
http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=4028

Figure 12. Photograph of Majuro Atoll
http://theextinctionprotocol.wordpress.com/2011/02/21/high-tides-and-rising-ocean-levels-flood-homes-in-mars nds/

Figure 13. Photograph of coral reef by Joe Ruhinski
http://fullhdwp.com/coral-reef-marshall-islands-majuro-atoll-wallpaper/

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