Climate Change in the Marshall Islands

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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 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 larger area. When scientists describe the climate in a place, they use measurements and observations of the weather that have been made over periods of 30 years or even longer. The climate in a place has very big effects on the plants, animals and people who live in that place.

The Marshall Islands have a climate where the weather does not change that much over the course of a year. 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 (see **Figure 1**).

Figure 1 *Many locations on our planet have four seasons, such as a very cold winter (top), a warmer spring (right), a hot summer (bottom), and a cooler fall (left) when leaves change color and fall off the trees.*

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Climate describes what kind of weather you can expect to happen. Weather describes what is actually happening. If you visit a place in the winter that has a climate with very cold winters, you should expect that it will be very cold. However, the week that you visit, the weather could actually be warm. It was probably cold the week before, and it will probably become cold again the week after you leave.

What is the climate in the Marshall Islands?

Warm with High Humidity

The climate in the Marshall Islands is generally warm and breezy with high humidity. The map (see **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. Air above warm ocean water is heated by that water, and also has a lot of water vapor in it making the air *humid*. The warm ocean around the Marshall Islands helps keep the temperature warm at night, and makes the air feel warm and humid.

Wet and Dry Seasons with Variable Rainfall

The weather and climate in the Marshall Islands 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 wet season and a dry season.

The wet season is usually from May to November, and the dry season from December to April. 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 cm) 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 cm) of rain in a year.

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

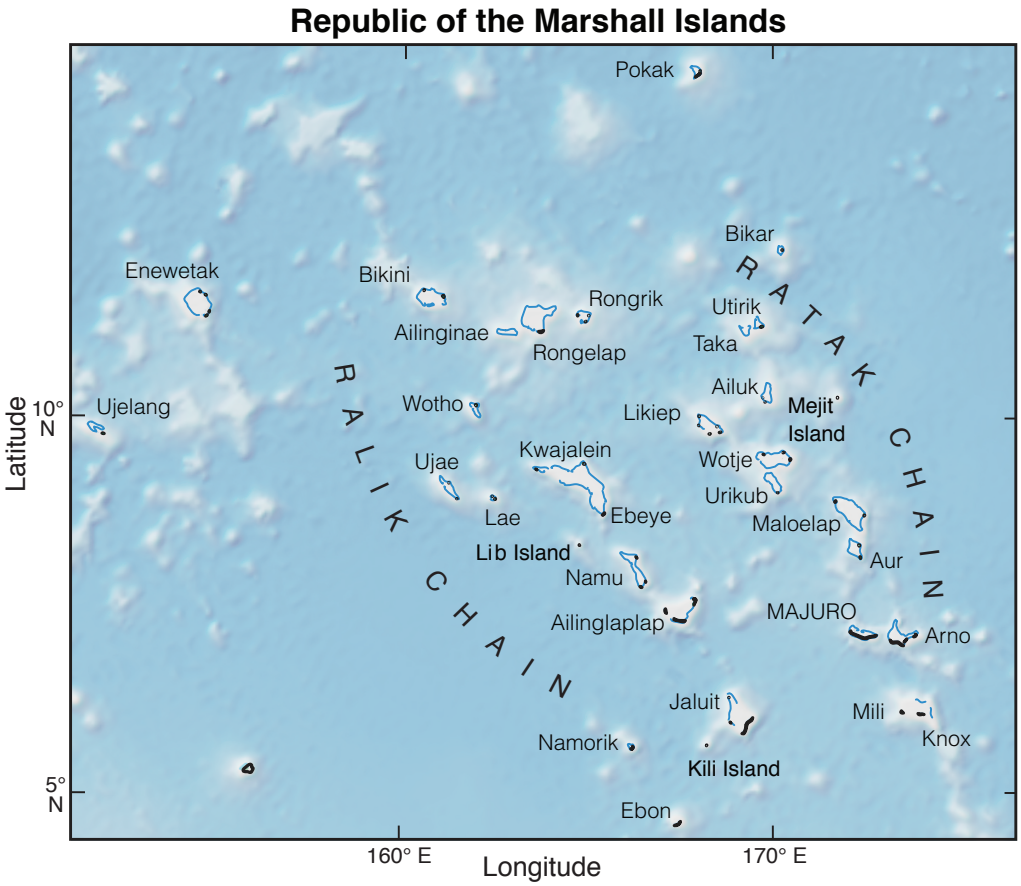

Figure 3 *RMI is mostly located at latitudes between 5°North and 12°North. Atolls at 10°N and further north generally receive less rain, especially in the dry season.*

Figure 4 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 cm) or more of rain, while other years had 90 inches (229 cm) 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).

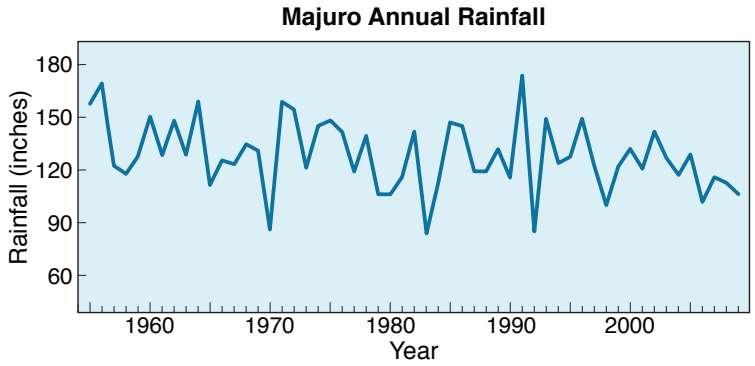

Figure 4 *The amount of rainfall in Majuro has a lot of variability.*

The winds near the equator usually blow from the east to the west. These winds are called *trade winds*. Near the equator, the trade winds in the northern hemisphere and trade winds 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 5**) as a band of thunderstorm clouds somewhat north of the equator.

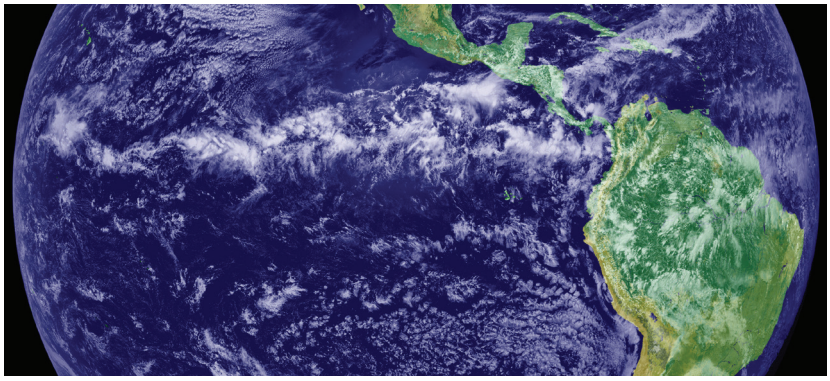

Figure 5 *The strong sun and warm water of the equator heats the air and increases its humidity. The warm humid air rises and becomes colder as it gets higher in the atmosphere. As the rising air gets colder, the water vapor condenses and forms big clouds that release the water in thunderstorms.*

This long band of rainy area near the equator does not just stay in one place. From May to November, the area of rain tends to move to the north (closer to the Marshalls) and causes the wet season in RMI. From December to April, the area of rain tends to move further south away from the Marshalls, and causes the RMI dry season.

Variable Trade Winds

The trade winds that usually blow from east to west play a large climate role in the equatorial Pacific Ocean. These winds can change during a climate feature that is called the El Niño Southern Oscillation (ENSO). When these winds are weaker than usual, scientists say that it is an El Niño year. When the winds are stronger than normal, scientists call it a La Niña year. **Table 1** summarizes the differences between El Niño years, La Niña years, and neutral years (normal trade winds).

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 trade winds	Weaker east to west trade winds; can even blow from west to east	Stronger east to west trade winds
Rainfall	Usual amounts of rainfall with normal variability	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 high tides tend to cause less flooding	Higher sea levels so high tides tend to cause more flooding

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.

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. **Table 2** summarizes the main features of the climate in the Marshal Islands.

Table 2

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

- Warm 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 trade 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 Intertropical Convergence Zone

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, and even the polar regions have little or no ice.

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

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 6**). This trapping of heat in the atmosphere is causing Earth's climate to get warmer.

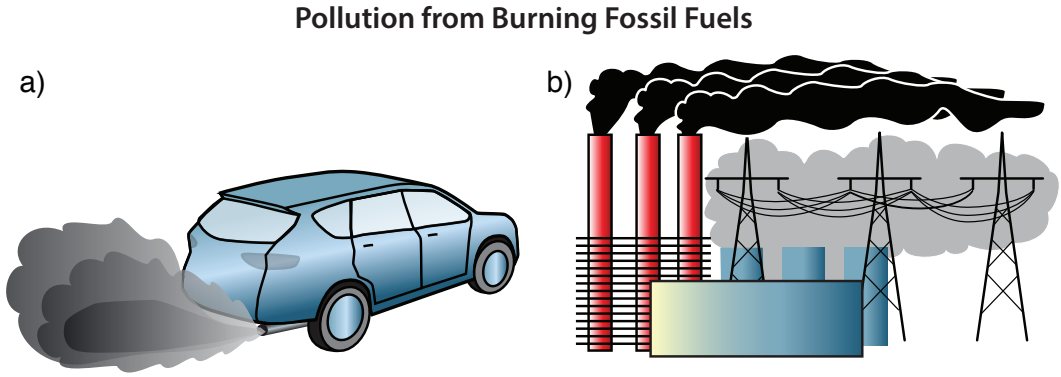

Figure 6 *When we burn fossil fuels (oil, coal and natural gas), they produce gases that stay in the atmosphere and trap heat, causing global warming. a) Oil is used to make gasoline to run cars and trucks. b) Oil, coal and natural gas are burned to make electricity.*

The graph of average global temperature over the past 130 years shows that the global temperature has been increasing (**Figure 7**). The temperature data are collected from weather stations around the world and cover the period 1880 to now. 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.

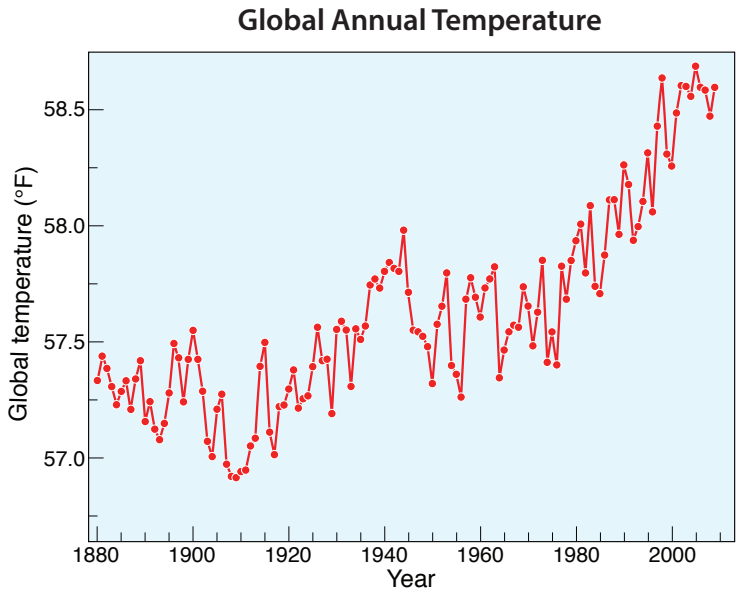

Figure 7 *The annual average temperature of the air close to Earth's surface.*

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 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 *global climate change* to describe this issue, rather than global warming. Some of these global climate changes are listed below.

1. Glaciers everywhere in the world are melting.
2. Sea level is rising.
3. The oceans are getting warmer.
4. Ecosystems are moving away from current locations toward locations that are not as hot.
5. Spring is coming earlier in places that have four climate seasons.
6. More of the planet is having tropical climate.
7. 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. Global 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?

The four most important impacts (damages) of climate change on the Marshall Islands are:

- Higher air and ocean temperatures
- Sea level rise
- More drought
- Ocean acidification

Global warming means that **air and ocean temperatures are warmer**. These higher temperatures can directly harm ecosystems and human communities, and is itself an impact of climate change. 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 (**Figure 8**).

Higher ocean temperatures cause the oceans to have a larger volume[1]. 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. 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, the most damaging impact of changing rain patterns is that droughts will probably get more severe. They may happen for longer periods of time. Droughts could also happen more frequently because of climate change.

Ocean acidification is another major impact caused by higher carbon dioxide levels. When carbon dioxide dissolves in the ocean, it forms a weak acid. This natural dissolving of the extra carbon dioxide 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.

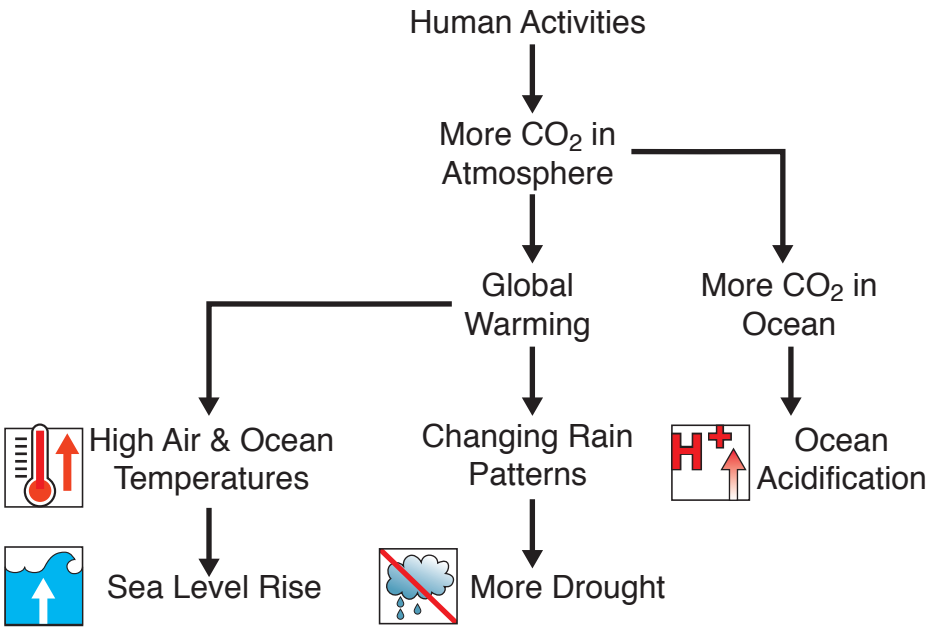

Figure 8 *Human activities, mainly burning fossil fuels, are putting more heat-trapping gases, especially carbon dioxide, into the atmosphere. These activities are causing global warming. The four major impacts of climate change in the Marshall Islands are shown with a graphic image next to each one.*

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

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 8** (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 9**).

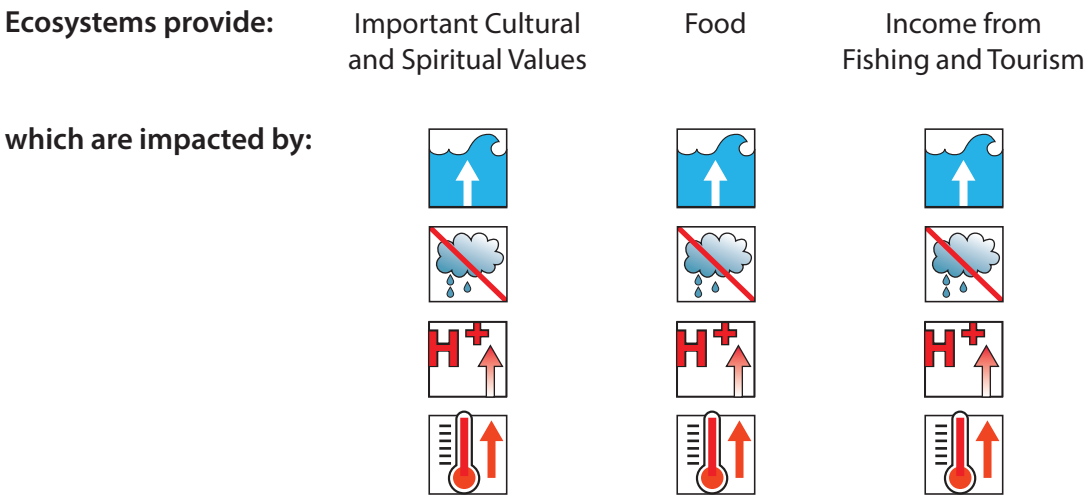

Figure 9 *Sea level rise, drought, ocean acidification and higher temperatures all damage major services that are provided by ecosystems.*

In addition, climate changes harm the human systems that people depend upon for their homes, food, fresh water, and transportation (**Figure 10**).

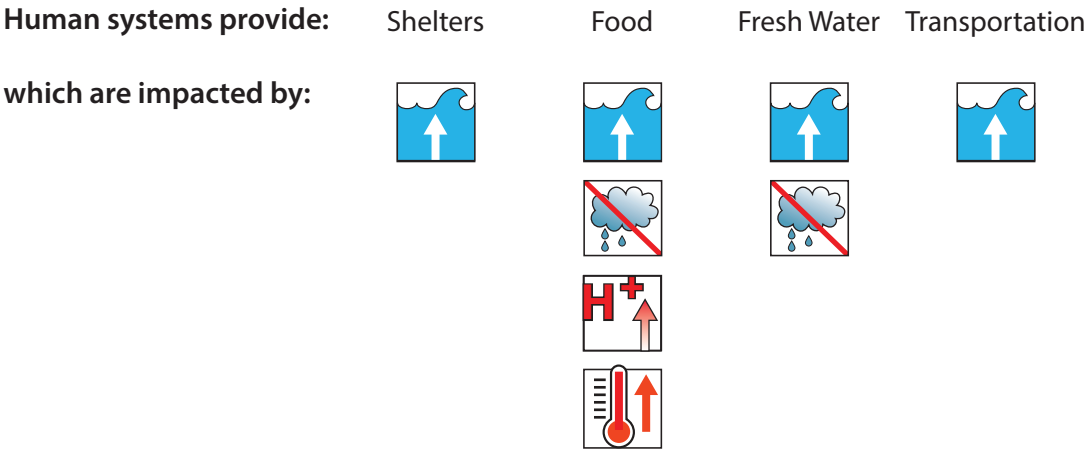

Figure 10 *Climate change damages major services that are provided by human systems.*

Sea level rise is especially important since it harms essentially all Marshall Island ecosystems and human systems. Since 1993, sea level rise has been occurring around the Marshalls at about 0.3 in/year (7 mm/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 high tide or a large storm) will cause more flooding than when the sea level was lower. For example, in January of 2011 serious flooding (**Figure 11**) 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.

Figure 11 *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.*

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.

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 12**). Coral are very sensitive to increases in temperature. Since the 1970's the water has warmed about 0.8°C (1.4°F) across the entire nation of RMI. 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 of the coral reef itself 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 12 *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.*

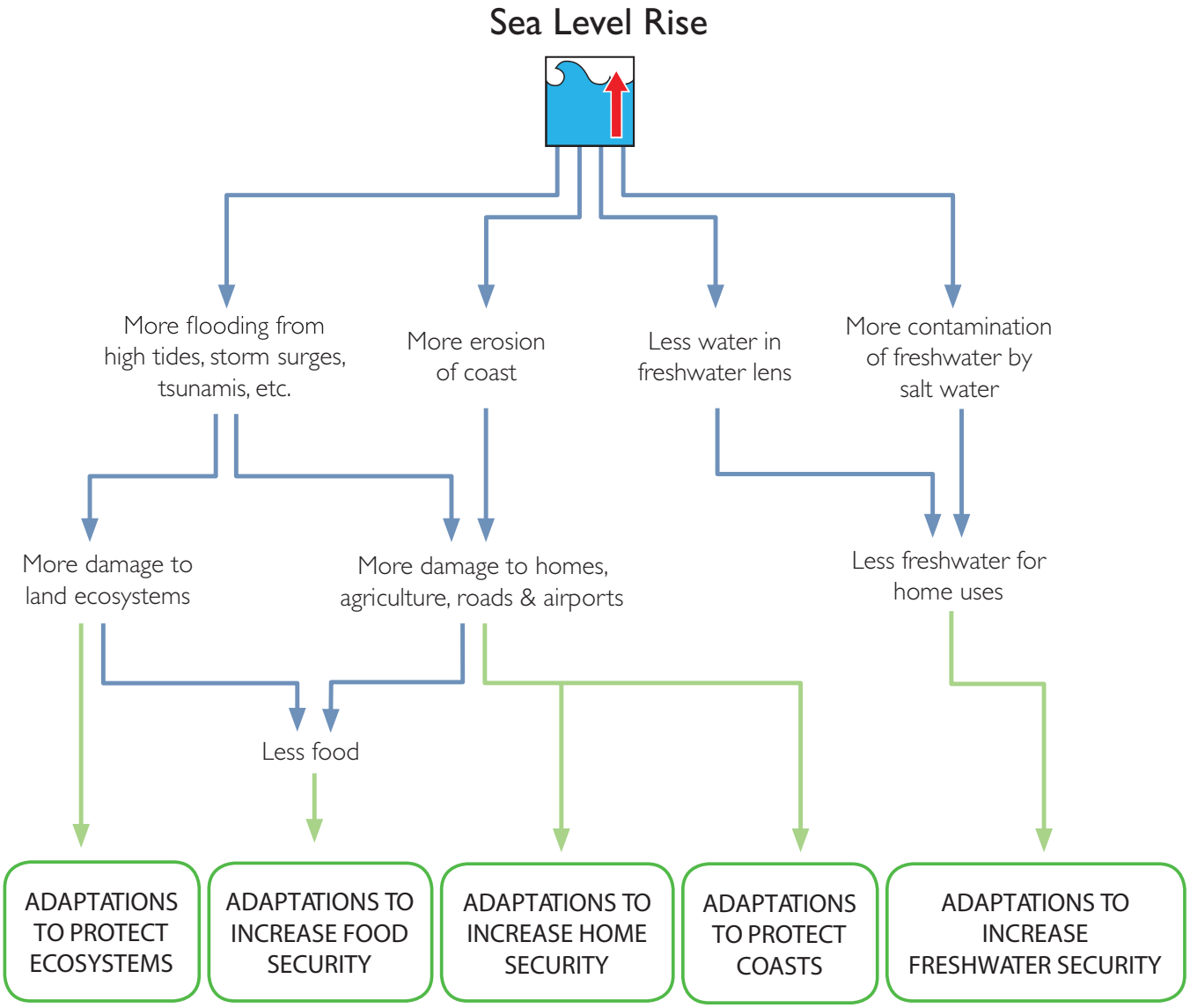

Figure 13 *Impacts of sea level rise and kinds of adaptation strategies.*

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 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.

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 freshwater, 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.[2]

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.

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

Acknowledgements

This essay has been produced by the Pacific Islands Climate Education Partnership (PCEP) as part of its work funded by the National Science Foundation (NSF) under Grant #1239733. The NSF funds research and education in most fields of science and engineering. Grantees are wholly responsible for conducting their project activities and preparing the results for publication. Thus, the Foundation does not assume responsibility for such findings or their interpretation.

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

Photographs

Figure 5 Photograph of the Earth
http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=4028

Figure 11 Photograph of Majuro Atoll
http://theextinctionprotocol.wordpress.com/2011/02/21/high-tides-and-rising-ocean-levels-flood-homes-in-marshall-islands/

Figure 12 Photograph of coral reef by Joe Ruhinski
http://fullhdwp.com/coral-reef-marshall-islands-majuro-atoll-wallpaper/

Feedback

What do you like or do not like about this booklet? We want any comments or advice that can help improve this booklet. Please share these with us by email to asussman@wested.org

We aim to produce similar booklets for other Pacific Island countries and states, especially those that are affiliated with the United States.