

Ava Smith
Danville High School
Danville, IA
Maldives, Marine Aquaculture and Sustainable Energy

Maldives: Ocean Acidification and Climate Change

When most people think of the Maldives, they often picture the outstanding beaches and tourism that fuels the country's economy. However, crystal clear water and vibrant reefs only skim the surface of what the Maldives actually comprise. This small country consists of nearly 1,200 small islands that are structured in twenty-seven coral atolls arranged in two chains. The atolls are found atop a 960 kilometer long submarine ridge that runs North to South across the Indian Ocean. Because most of the surrounding waters are shallow, there are realistically only two passages that permit access through the Indian Ocean, both located in the territorial waters of the Maldives on the southern end of the atolls. Since 99% of Maldivian territory consists of ocean, this country attracts many tourists striving for its clear waters and appetizing seafood. The Maldives attracts an average of 1.2 million tourists per year, making tourism the most prominent factor in Maldives' economy. Tourism alone accounts for twenty-eight percent of the country's gross domestic product (GDP).

With a small population of approximately 538,000 people, many of the islands have very low populations or are even uninhabited. In 2019, there were nearly 7,000 more births than deaths, ranking the Maldives as the 70th fastest growing population in the world. Additionally, only 34.5% of the population is urban. While its hot tropical climate is adequate for growing a variety of fruits and vegetables, just ten percent of its land is cultivated with mainly taro, bananas, coconuts, and other fruit. This is because Maldivian soil is highly alkaline and sandy, making any crop extremely difficult to grow. It also has nitrogen, potash, and iron deficiencies that substantially limit its agricultural potential. The Maldives are extremely flat and low-lying islands with no hills or rivers, as the most elevated one sits only three meters above sea level. This makes the Maldives extremely vulnerable to economic and food security devastation related to oceanic changes.

The Maldives has an extremely young population, with only three percent of their people over sixty-five years old and nearly half of them under fifteen. A fourth of its population lives in the capital city, Malé. 94.9 percent of Maldivians are employed primarily in fisheries, tourism, or government work. Most women find work in education, healthcare, and tourism. Education is accessible for all Maldivians with the intent that they will work in order to improve the country's economy. Fortunately, ninety-eight percent of the people are literate. However, secondary schooling is still significantly limited and male dominant, making it difficult for women to further their education beyond primary schooling.

Though the government lacks an organized welfare system, they focus heavily on improving education, social services, and preventive health services. In effect, healthcare improvement has decreased the Maldives' general death rate along with its infant mortality rate. In just a span of ten years, life expectancy has gone from only sixty-one to seventy-one years of age. Despite these improvements,

seventeen percent of children are underweight by the age of five. Along with this, micronutrient deficiencies occur often among all age groups. For instance, sixteen percent of children have zinc deficiencies and nineteen percent have iodine deficiencies. These shortages are also common for reproductive aged women. Approximately forty-four percent are Vitamin A deficient and thirty-eight percent are iron deprived. Most family diets consist of protein-enriched rice and fish. Fisheries play a prominent role in a family's food accessibility, as they do in many other developing countries as well. The Maldives heavily depend on fish as the most available and cheapest protein source, but as ocean acidification and climate change challenges surface, the resulting decrease in fish populations create new struggles for Maldivian people.

Seafood is responsible for over half of the protein vital to the Maldivian diet. For more than one billion of the poorest people on Earth, fishing is one of the most accessible ways to get the protein they need to live. However, seafood is not only used as a food source. For the Maldives, seafood is a major source of income for thousands of small-scale fishermen. Added to that, the amount of careers created from marine tourism has largely aided in the development of the country. Approximately thirty percent of the Maldives' population is employed in fisheries. Until 1985 when the tourism industry picked up, the fishery industry was the greatest contributor to the country's GDP. Skipjack tuna, yellowfish tuna, and a variety of reef fish are the most common catches. A relatively large 2.86% of the world's coral reefs are found in Maldivian waters. More than 30,000 tons of reef fish are caught for commercial use annually. Tuna fishing, particularly skipjack, is the most popular fishing industry. Skipjack tuna comprises about fifty percent of the total catch, and yellowfish tuna takes up about seventeen percent. Ninety percent of the total fish catch and most of the tuna is caught using the eco-friendly, traditional pole-and-line method.

Climate related disasters cause hundreds of billions of dollars to be lost each year. Beyond the money, climate change threatens hundreds of countries' food security. In the last forty years, sea levels have risen by approximately twenty centimeters. By 2100, they are estimated to rise another thirty to 122 centimeters. In the Maldives, islands consume anywhere from 3,000 to 8,000 liters of diesel a day. Not only is this a pollutive way of producing energy, but it also lacks efficiency. Using diesel as a main energy source is also very expensive because all that is used has to be imported. Human interferences, such as burning fossil fuels for energy, alter the chemistry and temperature of oceans. These changes redistribute marine species that the Maldives and many other countries depend on to polar areas. They have adapted to certain temperatures and conditions, so the warmer the oceans become, the more these animals stray from their tropical habitats, therefore halting food provision for these countries. This migration of fish and other marine animals threatens the Maldives' food security and the productivity of fisheries, harming their economy as well.

Many marine species use a mineral called aragonite as a building material for their shells and skeletons. Aragonite saturation varies along different types of coastlines that experience different levels of pollution, like agricultural runoff and sewage. Large emissions of carbon dioxide and ocean acidification cause the reduced aragonite levels. By 2050, many regions of oceans will have extremely low levels of aragonite saturation. If the levels get low enough, coral reefs will die at a quicker rate, adding another threat to fish populations.

In 1990, carbon dioxide emissions were sitting at 22.4 billion metric tons. Since then, these toxic emissions have increased by more than fifty percent. About thirty percent of the carbon dioxide we produce is absorbed by the oceans. Since the beginning of the Industrial Revolution, ocean acidification, which is the decrease in the pH of earth's oceans, has increased by twenty-six percent. This suggests that instead of improving our habits, humans are continuing to hurt the environment. Oceans have become 30% more acidic in just the past one-hundred fifty years. If ocean acidification continues to occur at these levels, thousands of food chains, coral reefs, and marine animal populations will suffer. For humans, this means losing some of the most accessible food sources for developing and third-world countries.

As pole-and-line fishing is one of the most sustainable ways to catch fish in the Maldives, the government has put forth much effort into making sure this method is used as much as possible. Regulations even ban the use of nets to catch tuna in order to minimize bycatch, or the unwanted species caught. However, there are many issues that are not being properly managed. In recent years, export values for reef fish species have increased. As reef fishing became more popular, locals exploited the species and resources they had access to through their fish markets, causing a drastic downfall in fish populations. Reef fish typically have low reproduction rates and therefore have difficulty in recovering their populations from exploitations such as these. Another problem the Maldivian people are facing is the use of harmful fishing methods by foreign nations. Foreign vessels tend to poach and over-exploit marine species on the outer sectors of the Maldives' exclusive economic zone (EEZ). They use methods such as purse seiners and fish aggregation devices (FADS) that have enormous amounts of bycatch. Purse seining is a fishing method that uses large nets to trap schools of fish, often tuna, all at once. While this method is extremely cost effective, it has significantly higher levels of bycatch and is conclusively detrimental to fish populations. If the population of skipjack tuna continues to decrease, the Maldives may have to turn to cheap and processed imports. Countries that have made this shift have suffered from a variety of diseases. Forty percent of the population in Pacific Island nations has cardiovascular diseases, diabetes, or hypertension.

The Maldives almost completely depends on imported diesel as an energy source. However, there are more sustainable ways for small tropical islands, including the Maldives, to produce energy. Studies show that energy demand in the Maldives is increasing. This increasing demand needs to be met with more efficient, cleaner, and cheaper ways to produce energy. The Maldives need to start using the renewable energy sources available to them. Since the Maldives receives an average of ten hours of sunlight per day, the energy source with groundbreaking potential is solar photovoltaic energy. It is reasonably easy to operate and maintain and also has the greatest generation potential overall. An alternate energy source, wind generation, is also available to the Maldives. However, compared to solar energy, it is more difficult to install and operate on such a small island with limited land area. Solar photovoltaic and wind energy could also be used to air condition homes, which is a popular need in the Maldives. They can produce and store ice that can be used as air conditioning for homes, which is significantly cheaper than diesel generation previously used. Ice-powered air conditioners can be substituted for air conditioners that use large amounts of power. They use the ice that they produce at night to cool the refrigerant during the day, conditioning the homes without using excessive amounts of electricity.

To maintain fisheries as a sustainable resource, it is important that the Maldives establish more marine protected areas. These protected areas can be solely used to regenerate fish and other marine animal populations. Aquaculture is a highly effective method used to restore populations of threatened or endangered species of marine animals. Aquaculture balances the increasing demand for seafood and the available resources by making it possible to breed and harvest marine creatures in coastal waters and even the open ocean. Typically, fish populations and habitats are restored in enclosed, net pens. Aquaculture has been proven successful by many countries. Marine aquaculture is used in the United States to generate species such as various types of mollusks, shrimp, seaweed, and fish. It is immensely important in providing our country with a stable seafood supply, which includes rebuilding species and habitats and increasing coastal resilience. These aquaculture areas are unavailable for fisheries and limit local pollution, which can create better toleration among coral reefs and other ecosystems to the changing chemistry of oceans. Aquaculture could potentially solve much of our planet's food security and climate change problems, as it has one of the lowest greenhouse gas emissions out of all farming techniques.

Many species could benefit from aquaculture in the Maldives, but the one with the most potential is reef fish. Reef fish are very popular in the commercial sectors of the islands. Excursions and other various fishing trips occur often, and while these play a key role in the country's economy, they damage the viability of reef fish. The slow reproduction tendencies of reef fish make them more susceptible to endangerment compared to other species. On top of that, they play an important role in several economies and ecosystems. Reef fish, along with many types of tuna fish, are being fished in unsustainable ways. International poaching in the Indian Ocean is common, often just outside the exclusive economic zone of the Maldives. Tourist resorts and fishing excursions commonly report their total catch or their total bycatch dishonestly, providing the Maldives with invalid numbers. While there are many regulations in place for total fish catch, where fisheries can and can't fish, etc., when fisheries don't properly report their fish data and poaching occurs those regulations are disregarded. Therefore, it is vital that proper research and reports are filed on the fish species' population status, behavior and biology, and the economical effect it will have before any fishing of the species takes place. If the Maldives begins requiring all resorts and fisheries to give precise reports, overfishing rates will be diminished and fish stocks will be a more sustainable resource for the country.

As mentioned before, solar photovoltaic energy is the best option for the Maldives. Even so, there are some problems the Maldives will face in switching to photovoltaic energy. Obviously, solar and wind energy are not available one-hundred percent of the time. Therefore, in order to get maximum generation from these sources, batteries or other available energy-storing technologies will be needed. Solar photovoltaic energy also requires space, which is scarce in the small islands of the Maldives. A Vienna solar company called Swimsol created photovoltaic panels that can be situated on floating platforms and placed in the ocean, employing absolutely no land space. When they are installed, they are never placed over corals. Instead, they are anchored in empty patches of the seabed where they cannot harm the surrounding ecosystems. Most panels can only tolerate up to two meters of ocean waves, so panels are generally anchored close to islands. Electricity can be transferred through the grid using undersea cables, which allow sustainable energy to reach any of the islands. Swimsol has recently installed SolarSea systems (floating photovoltaic systems) in several small developing countries. The company's engineers

consistently maintain the systems on a regular basis. Despite being relatively expensive to install, SolarSea generation costs were reported to be less than \$0.20 USD per kilowatt-hour, which is significantly lower than the costs of importing and using diesel in the Maldives. If developed properly, these systems could subside reliance on imported diesel and drastically lower the prices of electricity.

The effects of switching to sustainable energy processes will change the fate of small island countries drastically. For the Maldives, their security depends on creating small changes to their fishing habits and making use of the renewable energy available to them. While tourism is the main economic sector, it is unpredictable and cannot be depended on. Therefore, the proper management of fisheries is vital in the Maldives' food security. In addition, aquaculture provides added stability to fish populations while also creating employment and aiding the country's economic growth. Switching to solar energy is the most drastic change needed, but it will save the Maldives millions of dollars while also employing a much more sustainable form of energy. If developing island countries continue to depend on oceans for economic and food security, necessary changes need to be made to ensure their main resources remain available.

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