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Reasons for International Concern: The Detrimental Effects of Climate Change and Pollution on the Planet's Coral Reefs

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Abstract
This research paper delves into the destructive effects of climate change and pollution on coral reefs in the hope of bringing awareness and helping to reverse the damage done. It addresses the question of why coral reefs are essential to living organisms and how one, as an individual can take action to combat the issue at hand. It also aims to highlight the critical need for a coordinated plan of action by shedding light on the detrimental effects, such as coral bleaching and ocean acidification, have on our reefs.

Keywords: Coral bleaching, ocean acidification, sustainability, global warming.

Literature review

Throughout this research paper, I will be exploring the topic of loss of biodiversity and the ecosystem. In this matter, I will be further discussing how climate change and pollution are having an adverse effect on the earth's coral reefs. This question is relevant to today's society as the majority of the coral reefs all over the world's water bodies have been reported to be bleached and dying due to the onset of multiple stresses.

If we fail to do anything to prevent this mass threat from causing the extinction of these majestic coral reefs, life on Earth as we know it, will cease to exist. This is not an exaggeration, as the destruction of these coral reefs, will not only cause an economic catastrophe as it is estimated over one billion people depend on reefs to survive (Carilli,2013), but it will cause one of the world's most biologically biodiverse ecosystem to become extinct.

Coral reefs are home to millions of wildlife around the globe, they are often referred to as the rainforest of the ocean. They are diverse and complex ecosystems formed by the accumulation and growth of coral colonies. Most of the extraordinary reefs found today are said to be between 5000 and 10000 years old. (National Geographic Kids 2022). Though they make up approximately 0.08–0.16% of the world's oceans, coral reefs are home to almost one-third of all known marine species.

2. How is Climate change responsible for coral reef decay?

How is climate change affecting the coral in these reefs you might wonder? Worldwide, the burning of fossil fuels is destroying the earth's ozone layer and thus warming the whole planet. This causes the melting of ice and alternately rising sea levels. The earth's bodies of water have been absorbing the majority of the heat, about 90% so far (NOAA Climate 2020). If the oceans weren't absorbing the heat, the average temperature on land would be fifty degrees Celsius. This causes the water to rapidly warm and is what affects the reefs. The first time this was observed was in the 1970s when scientists noticed the corals losing pigment and becoming colourless. They wondered why that occurred and went about doing a series of tests and experiments.

2.1 Coral bleaching

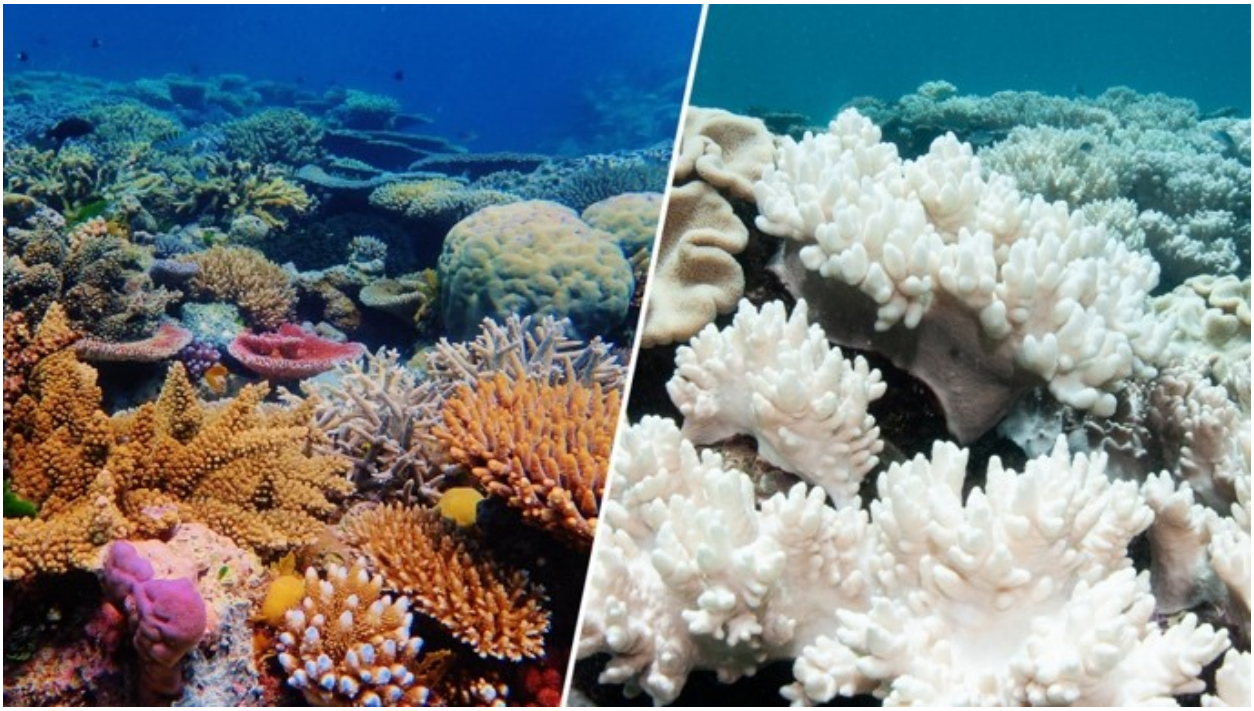

Figure 1. *shows the comparison between healthy coral and 'bleached' coral. (NBC 6 South Florida)*

In the end, the most certain thing causing the corals to become "bleached" was the rise in the water temperature by as little as two degrees, proving their hypothesis correct. The component the corals lose when this happens is the expulsion of symbiotic algae called 'zooxanthellae', which gives them vibrant colour and helps them produce food. Without it, it slows their growth and makes them more vulnerable to disease and eventually death. Bleaching is a stress response from the temperature rise, much like how our bodies have fevers (National Ocean Service, 2021). The first global-scale mass bleaching occurred in 1980, ten years later in 2010 another one ensued. The years in between these mass bleaches continue to rapidly decrease, resulting in coral dying at a much faster rate than they can reproduce

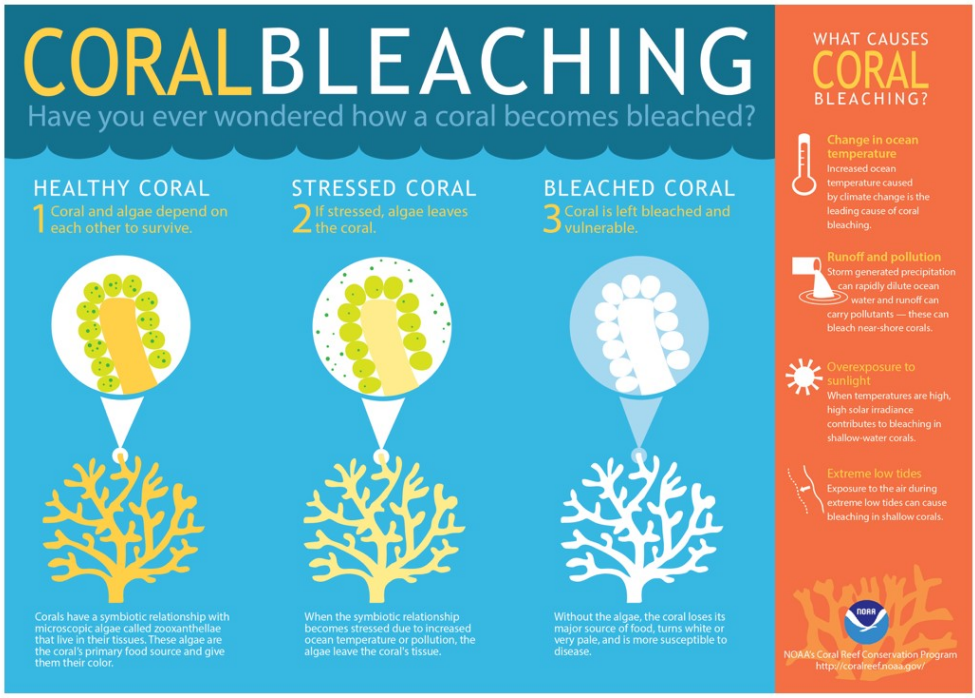

Figure 2. *illustrates how coral bleaching occurs.*
(National Ocean Service- National Oceanic and Atmospheric Administration NOAA)

Example of coral bleaching.

A famous example of coral bleaching is the Great Barrier Reef, located off the north-eastern coast of Australia, and known for being the largest coral reef in the world. If you were to ask someone born in the year 1970, they would describe the reef as colourful and enormous, unfortunately, our generation will only know stories at this rate as over 50% of the world's coral reefs have died in the last 30 years. It is predicted that 70-90% of the coral globally will vanish in the next two decades according to scientists from the University of Hawaii Manoa. The 'Status of Coral Reefs of the World: 2020' report, estimated that approximately 14 per cent of the earth's coral has died since 2009.

Figure 3. *Illustrates sight where mass bleaching has taken place.*
(Australian Marine Conservation Society)

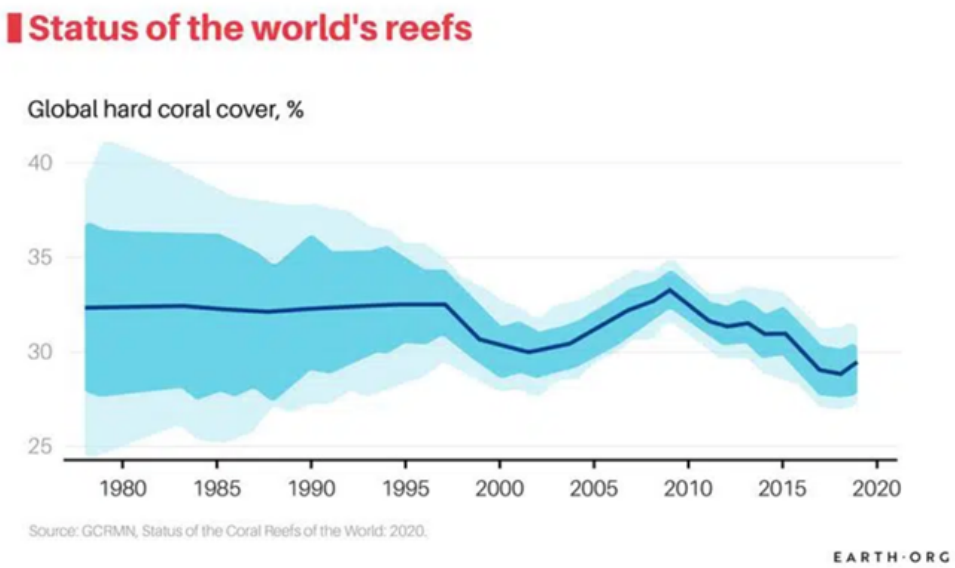

Figure 4. *Shows the decrease in the earth's corals between the years 1980 to 2020.*

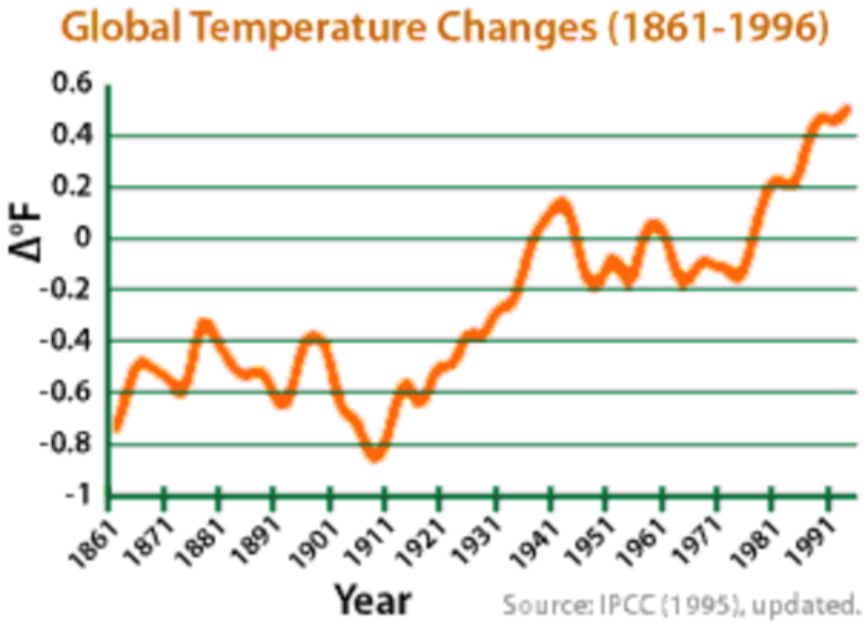

Figure 5. *Shows the increase in global temperatures.*

The earth's temperature is continuously rising, as in 2022 record-breaking heat waves caused temperatures to upsurge to those not experienced since the late 1850's and continuously rise as seen the next year. In 2023, temperatures all around the globe skyrocketed during the summer with the northern hemisphere reaching the hottest it has ever been in history. Unfortunately, this simultaneously caused our oceans to absorb the majority of the intense heat to reach record-high levels.

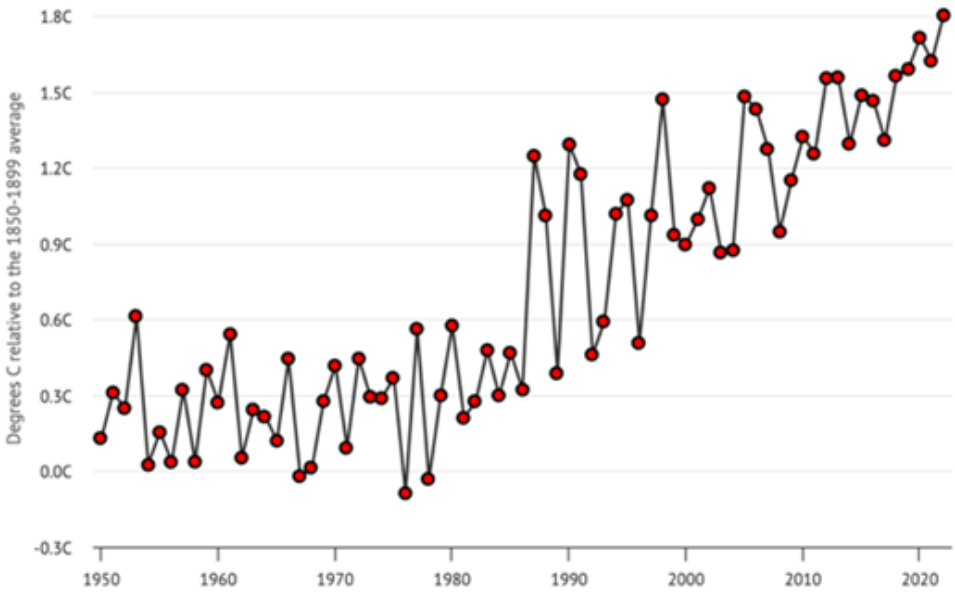

Figure 6. *Showing the rise in land temperatures during summer.*
(Using Copernicus/ERA data from 1850 & 1950 calculated from the Berkeley Earth dataset)(State of Climate)

3. Why are Coral Reefs Vital?

The reefs contribute greatly to not only the environment but also mankind, they provide food to billions, offer careers, supply natural medicines, and protect the land from natural disasters such as storms and tsunamis (National Ocean Service 2021). The catastrophic massacre occurring in these reefs would have detrimental consequences for both humans and other organisms.

3.1 Key justifications why these reefs are essential to human beings.

3.1.1 Oxygen

One of the most essential aspects of coral reefs for humans is undeniably the oxygen they provide. They are not merely underwater landscapes but a vital source of oxygen. In an interview with Michael Crosby, a marine scientist and president of Mote Laboratory and Aquarium, he asked the interviewer "You like to breathe?" Crosby continues: "Estimates are that up to 80% of the oxygen we are breathing in right now comes from the ocean." This percentage shows how truly important it is to have a healthy ocean and how corals contribute to that.

3.1.2 Occupation and Food Security.

The majority of coastal communities depend on coral reefs as a form of income which is essential to provide for their families. Fish species that use coral reefs as a breeding and feeding ground contribute significantly to global fisheries as approximately half of all federally managed fisheries are only sustained due to coral reefs. The National Marine Fisheries Service estimates that the commercial value of U.S. fisheries from these reefs is over $100 million.

The decline of coral reefs would impact the fish population, leading to reduced catches and compromising food security for millions of people.

3.1.3 Economic impact

The destruction of these coral reefs, will not only cause an economic catastrophe, as it is estimated over one billion people depend on reefs to survive (Carilli,2013) but it is estimated that $30 billion annually are provided by coral reefs through food, fisheries, and tourism. (Hopkins Marine station of Sandford University)

To fully explain how coral reefs will impact the economy we can examine the country of Barbados, a Caribbean Island, located in the Caribbean Sea. The country is known for its beautiful beaches and is a popular tourist attraction mainly for this reason.

The economy is driven predominantly by the revenue of tourism and deprived of it, the island's economy would not survive. The people of Barbados depend financially on the constant flow of tourist cash dollars for their livelihoods.

3.1.4 Costal/Shoreline Protection

Coral reefs act as a natural barrier protecting human life and property, preserving the coastline from erosion and storm surges by damping the rough waves. This is attributed to the physical structure of the reefs which help absorb and disperse the energy of the waves.

They can significantly reduce coastal flooding by dissipating as much as 97% of incident wave energy. Therefore, the loss of these reefs would leave coastal areas vulnerable to the destructive forces of waves and storms.

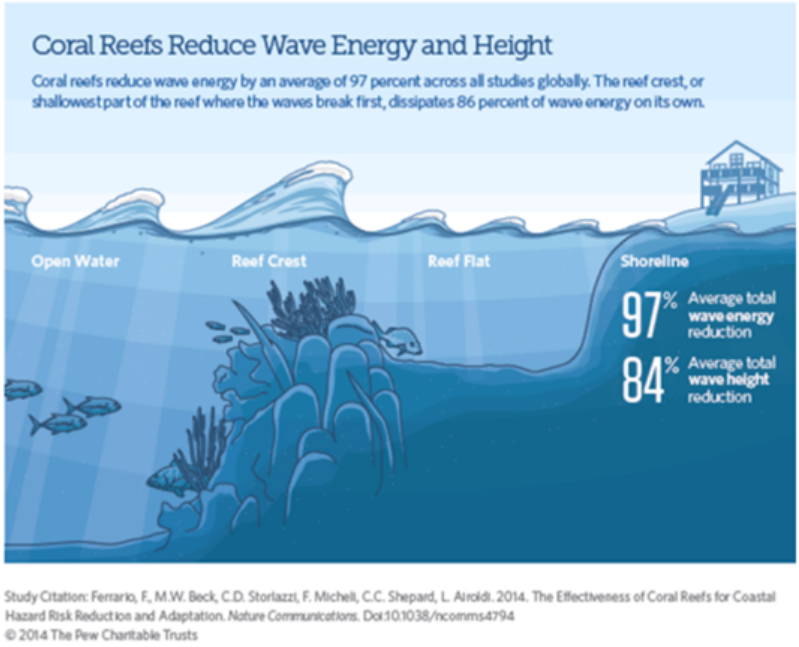

Figure 7. *Depicts coral reefs decreasing wave height.*

3.1.5 Medical resources

Novel chemicals and medication may be found in coral reefs. Currently, certain coral species found on reefs generate chemical compounds that have been used in an approach to treating cardiovascular disease, ulcers, leukaemia, lymphoma, and skin cancer. Ongoingly numerous beneficial products are being derived such as an algae-based cancer treatment and a

painkiller taken from the venom in cone snails. Due to the multitude of reefs, immeasurable amounts remain undiscovered, meaning the loss of these valuable resources could impede future medical advancements. More than 50% of all new cancer drug research is focused on marine organisms found on coral reefs.

3.1.6 Education and Scientific Research

In summary, there would be a decrease in marine biodiversity as well as ripple impacts on human communities and the economy if coral reefs were to disappear. It is imperative that global efforts be made to conserve and protect coral reefs because of the interdependence of ecosystems and human dependence on healthy oceans.

3.2. Key justifications why coral reefs are vital to other marine life.

It is estimated that about 25% of all known marine species rely on coral reefs for their survival.

3.2.1 Food

A vital source of nourishment for a variety of creatures is found within coral reefs. Numerous fish and invertebrate species feed on the reef ecosystem and add to the food chain in the surrounding marine environment as well as on the reef itself.

3.2.2 Shelter

One of the biodiverse ecosystems on Earth is the coral reef. They serve as a home to a staggering array of marine life, such as fish, molluscs, sponges, algae, and invertebrates. Because of the intricate structure of the reef, a wide variety of creatures can find hiding spots and niches.

3.2.3 Breeding

Coral reefs serve as a nursery and breeding habitats for numerous fish species. Young fish can find refuge and protection from predators because of the complex structure of the reefs. Many marine organisms are supported in their early life stages by the availability of food sources surrounding reefs.

4. Methods to prevent coral decay

In the long term, climate change is understandably and visibly more important. However, one person cannot halt climate change, but one can reduce human activities which are contributors thus causing negative effects on the coral reefs. We as human beings can take many courses of action to help protect our coral reefs and prevent their extinction. Researching this topic I found unsurprisingly that one of the major reasons coral reefs are dying is actually due to human activity.

4.1.1 Public Awareness Education on the topic.

Over time, even just being self-aware and knowledgeable about this issue might have a positive outcome. After decades of research, it was revealed that though scientists have developed the best suitable and effective sunscreen to protect your skin, the chemicals are extremely toxic for the reefs. What can seem like a negligible amount of this chemical was said to be enough to cause the bleaching of reefs. Thankfully, we can educate ourselves about this harmful chemical and choose a sunscreen without the ingredient oxybenzone as it is the one known to be toxic to corals.

4.1.2 Recycling

Littering is another major issue affecting the reefs. Human waste such as plastic: a nonbiodegradable, toxic material ends up in the ocean. This plastic debris can become entangled or ingested by marine life causing them to die. According to the United Nations, at least 800 species worldwide are affected. Up to 13 million metric tons of plastic end up in the ocean every year. This offsets the natural ecosystem and food chain.

Oil spills caused by ships are an element that when encountered by the coral, can kill or impede their reproduction, growth, behaviour, and development. The entire reef ecosystem can and will suffer from an oil spill.

4.1.3 -Reducing your carbon footprint

Ocean acidification

Another factor responsible for 'bleaching' is the increase in ocean acidification caused by the absorption of carbon dioxide (NOAA National Ocean Service 2021).

Ocean acidification, also referred to as the other effect of CO2 (Doney et al., 2009), because of changes in land use and the burning of fossil fuels, the concentration of carbon dioxide (CO2) in the atmosphere has been rising for almost 200 years, or since the industrial revolution. About 30% of the CO2 produced into the atmosphere is absorbed by the ocean, and as atmospheric CO2 levels rise, so do ocean CO2 levels. As per the United Nations Environment Programme (UNEP), there was an indication of the impact on coral reefs worldwide when the carbon dioxide level hit 390 ppm.

The concentration of hydrogen ions rises as a result of a sequence of chemical processes that take place when CO2 is absorbed by saltwater. As a result of this rise, carbonate ions are comparatively less common and the ocean becomes more acidic due to the formation of carbonic acid, which concentration leads to a reduction in the pH of seawater, making it more acidic.

Decreases in carbonate ions can make it more difficult for calcifying organisms like oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton to build and maintain shells and other calcium carbonate structures. These changes in ocean chemistry can also affect the behaviour of non-calcifying organisms, such as fish whose ability to detect predators is reduced in more acidic waters, which puts the entire food web at risk. Ocean acidification is affecting all of the world's oceans, including coastal estuaries and waterways. Many economies depend on fish and shellfish, and people around the world rely on the ocean for their daily sustenance.

Deforestation

In 2022 and ongoing in 2023, the unimaginable occurred, 11.8 million acres of the Amazon forest burnt between the months of January to September 2023 caused by selfish humans contributing to global warming for self-gain. The gas produced by the event of deforestation only leads to more destruction of our reef causing these underwater forests to further disintegrate. The reduced number of trees available to absorb CO2 from the atmosphere, through photosynthesis, results in higher concentrations of CO2 in the air, contributing to ocean acidification.

Preventing ocean acidification

The issue of ocean acidification is intricate and multidimensional, with significant ecological and socioeconomic ramifications. It will take international cooperation to cut carbon emissions and adopt sustainable methods to safeguard marine ecosystems in order to address the underlying causes of this phenomenon.

The most practical long-term approach is to reduce greenhouse gas emissions, which are the main cause of ocean acidification and climate change. Furthermore, it is imperative to make attempts to adjust to evolving circumstances. Examples of this include creating more robust aquaculture methods and putting marine conservation policies into place.

To help combat this issue it is essential to take initiative and reduce your carbon footprint. This can be done on an individual level by straightforward methods like:

1. Using energy-saving lightbulbs and appliances. When not in use, turn off the lights and gadgets.
2. Encourage the use of renewable energy sources, such as wind and solar energy. Install solar panels if you can, or ask your utility company to offer you a green energy choice.
3. Rather than driving your own car, consider taking the bus, carpooling, biking, or walking. Select electric or fuel-efficient cars if at all possible. To cut down on emissions from commuting, think about working from home or via telecommuting.
4. Minimise waste by material recycling, item reuse, and consumption reduction. Recycling lowers the quantity of garbage in landfills and the energy needed to produce new things.
5. Conserve water to reduce the energy associated with water treatment and distribution
6. Reduce your intake of meat or switch to a plant-based diet. The production of livestock contributes significantly to greenhouse gas emissions. Purchase seasonal, organic, and locally grown food to help promote sustainable farming methods.
7. When making purchases of goods and services, make educated decisions. Encourage the use of sustainable and eco-friendly products. Think about how your purchases, including the packaging, will affect the environment.
8. Minimise your flying because it emits a lot of carbon. When travelling, aim for buses or trains whenever possible.

It is an ongoing process that involves making mindful choices in various aspects of your life. These small individual changes, when multiplied across countries or even continents will have a meaningful impact on preserving the environment.

4.1.4 Sustainable fishing practices

Humans are overfishing in these areas and causing the food chain to become unbalanced. These fish have a symbiotic relationship with the coral. They help keep the underwater ecosystem stable as they eat the algae and parasites of the coral. Without them, it overwhelms the corals causing them to eventually die. (National Geographic 2019). While fishing, another factor causing the depletion of coral due to human activity is boats dragging anchors and nets along the ocean floor breaking and killing coral, destroying and damaging reefs.

4.2 How is the world preventing coral decay?

4.2.1 Coral Restoration Programs

They have developed methods to deal with these problems such as Coral Vita, the world's first commercial, land-based coral farm. Coral farming is the process of carefully raising broken-off coral fragments and reintroducing them into the water once they have become mature enough to survive. This process has helped and continues to aid in the recovery of coral reefs.

4.2.2 National policy

Individuals can advocate to their governments to implement policies and laws that address the risk to coral reefs. This could include laws that restrict overfishing, lessen pollution and protect coral habitats. Further, it would be essential to tackle global struggles with climate change harming coral reefs where international cooperation is crucial.
The Coral Reef Conversation Act is currently one of the actions implemented in the development and management of sustainable use of coral reef ecosystems. They provide financial resources to aid in the preservation of reefs.

The Paris Agreement is an international treaty adopted in 2015 with the goal of addressing climate change on a global scale. Its primary objective is to limit the increase in global average temperature to well below 2 degrees Celsius above pre-

industrial levels. The agreement embodies a cooperative and adaptable strategy to combat climate change, with countries cooperating to establish and meet their climate targets.

5. Is it already too late?

Despite the current threats, it is evidently not too late to salvage these underwater ecosystems, though the development of mankind has initiated a negative effect on the coral reefs. In the long term, these situations will result in irreversible consequences on the earth and will affect future generations. The Covid-19 pandemic (2020-2021), though it halted the efforts of key organization's operations from continuing to take action and attempt to save reefs, with underwater clean-ups. Without the interference of mankind and its toxic behaviour towards nature, the environment was able to replenish itself and begin thriving.

Within a few weeks, of the COVID-19 pandemic, the travel and other economic sector restrictions imposed by nations worldwide significantly reduced air pollution and greenhouse gas emissions. The abrupt shift provided scientists with a never-before-seen perspective of outcomes that would take years to attain under laws.

The scientists pointed out that the most unexpected finding was that, despite a 5.4% decrease in carbon dioxide (CO2) emissions in 2020, the amount of CO2 in the atmosphere grew at a roughly constant pace. Head of JPL's carbon department and research co-author David Schimel said, "You could immediately see a change in the growth rate of CO2 during previous socioeconomic disruptions, like the 1973 oil shortage." "We all anticipated seeing it this time as well.

First, although there was a notable 5.4% decrease in emissions, the increase in air concentrations was within the typical range of annual variation brought on by natural processes. Additionally, the ocean's absorption of CO2 from the atmosphere was less than it has been recently; this was likely due to an unanticipatedly quick reaction to the lower CO2 pressure in the air near the ocean's surface.

This gives us a glimpse of how prompt action could have favourable results. Coral reef recovery can be facilitated by international cooperation, governmental changes, and responsible personal decisions, despite the enormous obstacles.

Venice canals run clear, dolphins appear in Italy's waterways amid coronavirus lockdown. Picture: Getty/Twitter

Figure 8. *Shows how with the lack of human activity wildlife beings to flourish once more.*

5. Conclusion

To sum up, the detrimental impacts of pollution and climate change on the planet's coral reefs pose a serious threat that necessitates immediate attention and coordinated measures on a global scale. The escalating effect of climate change, driven by the rise in greenhouse gas emissions fueled by the pollution of our planet due to human activity poses a threat to the survival of these underwater ecosystems. Therefore, it is essential that us, human beings, take the initiative by not only spreading awareness in the hope to combat this issue but also take the necessary steps to collectively preserve our ocean's coral reefs.

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