



# Synthesizing the Ecological and Societal Ramifications of Environmental Stressors on Philippine Marine Ecosystems: A Comprehensive Literature Review

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**ABSTRACT:** Coral reefs, which serve as essential ecosystems that support marine biodiversity and coastal populations, are declining at an alarming rate worldwide, including in the Philippines. This study explores the specific effects of overfishing, the causes, and effects of pollution on Philippine waters to understand better rising sea levels, ocean acidification, the overall impact of climate change on coral reefs, and the value of these coral habitats to local communities. Data were acquired using a qualitative approach through literature reviews of secondary sources. The findings show that overfishing, pollution, climate change, and habitat destruction are major causes of coral reef decline in the Philippines. These factors have resulted in severe reductions in coral cover, biodiversity loss, and decreased ecosystem services. Furthermore, coral reef decline has far-reaching consequences for Philippine biodiversity, including decreased resistance to environmental stressors and greater vulnerability of coastal people. This study highlights the urgency for coordinated conservation initiatives, such as enhanced management tactics, sustainable fishing practices, and climate change mitigation measures. Recommendations include creating marine protected areas, stronger coastal development rules, and public awareness programs to support coral reef protection. Addressing coral reef loss is crucial for protecting Philippine biodiversity and ensuring the long-term viability of marine ecosystems.

**KEYWORDS:** anthropogenic impacts, coral bleaching, coastal management, community engagement, fisheries management, marine conservation, ocean acidification, sustainable development.

## INTRODUCTION

Coral reefs are degrading worldwide due to drivers directly or indirectly linked to human activities (Smith et al., 2016; Graham et al., 2017; Hughes et al., 2017). According to the Geography of the Philippines, the Philippines is an archipelago with 7,641 islands and a total land area of 300,000 square kilometers (about half the area of Texas) surrounded by coral reefs. De Vantier and Turak stated that its waters are renowned for having the highest biodiversity of corals and shorefish, and its total reef area, which is about 25,000 square kilometers, is the third largest in the world. Coral reefs are similarly becoming increasingly popular among both local and foreign tourists. Tourists are drawn to the Philippines due to its breathtaking scenery, beaches, and many water activities, including snorkeling and diving. Coral reefs provide necessary environmental services to humans, including fisheries, business opportunities, storm protection, and a source of income for over a million small-scale fisheries, contributing to the country's economy. Coral reefs also provide food, shelter, and breeding sites for a diverse range of fish, marine mammals, and invertebrates.

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more fish and coral species than any other marine ecosystem. The study intends to examine the various variables contributing to coral reef degradation, assess the ecological and socioeconomic consequences, and propose protection conduct. This study aims to provide valuable insight into preserving marine biodiversity and managing coral reefs in the Philippines.

The Philippine coral reefs are in poor condition. Human activities have negatively impacted marine reefs. The drivers of the coral decline are due to human activities such as overfishing, habitat destruction, pollution, and the effects of climate change. These effects have resulted in decreased tourism income, a loss of marine species' habitats, and reduced biodiversity. Without healthy coral reefs, these species face extinction or decline. Coral reefs are crucial in protecting coastal towns from erosion and storm damage. Their decline can also lead to decreased fish populations and threaten the livelihoods of many people who rely on fishing for their income. The tourism sector relies heavily on coral reef activities such as snorkeling and diving, and the decline of reefs can deter tourists and cause economic losses for coastal towns. Coral bleaching, a process caused by rising sea temperatures, makes coral prone to disease and upsets the delicate balance of the ecosystems (Eakin et al., 2004). As coral habitats decline, traditional practices are disrupted, and cultural identities are destroyed (Christie et al., 2017). For example, the Philippine reefs, including those in Bolinao, are declining in coral cover due to multiple disturbances such as pollution, overfishing, and seawater warming (Arceo et al., 2001; Hoegh-Guldberg et al., 2007).

Coral reefs are among the most environmentally and commercially significant ecosystems on earth. They cover less than 0.1% of the world's oceans, support more than 25% of marine biodiversity, and provide various ecological services, including coastal protection, fisheries production, medicine, recreational advantages, and tourism revenue (Burke et al., 2011). Conservation measures such as protecting marine areas and regulating land-based pollution are critical to coral reef resilience (Anthony et al., 2017; Mcleod et al., 2019). However, more active management and coral reef restoration are now needed to conserve and rebuild reef habitats, conserve climate action, and protect reef habitats (Duarte et al., 2020; Rinkevich, 2019).

The various aspects of coral reef decline are explored in this literature review, particularly emphasizing the drivers, impacts, and implications for the Philippines' rich biodiversity. This study digs further into the current conservation actions in the region and explores potential solutions to mitigate the hazards to coral reefs. (Selig et al., 2012; Eakin et al., 2019). The findings indicate that, while conservation efforts are in progress, more comprehensive and coordinated measures are required to safeguard coral reefs in the Philippines properly. The paper also emphasizes the significance of community involvement and stakeholder engagement in successfully implementing conservation strategies. There is hope for these essential ecosystems' future health and resilience by addressing the causes of coral reef loss and implementing sustainable management techniques.

The decline of coral reefs in the Philippines is a severe problem that seriously risks marine ecosystems. Overfishing, pollution, and climate change are the main causes of this decrease because they have caused coral reefs to degrade and bleach widely. Since coral reefs support a wide variety of marine species and offer vital ecosystem services, the impact of this decline on Philippine biodiversity is significant. This study aims to provide significant insight by evaluating and investigating the drivers of coral reef decline, assessing the effects on marine biodiversity, and analyzing the implications of biodiversity decrease in the Philippines. This study will suggest sustainable management techniques and essential information to support the Philippines' attempts to save its coral reefs. It will also be emphasized how crucial it is to preserve marine biodiversity for the sake of local populations and ecosystems in the future.

The Philippines holds one of the most extensive coral reefs in the world, with a sprawling area of 27,000 square kilometers strategically located in Palawan (37.8%), Sulu (27.8%), Visayas (21.7%), Northern Luzon (7.6%), Central and Southern Mindanao (3.2%), and the Turtle Islands (1.7%). A survey conducted by the Marine Science Institute of the University of the Philippines at Diliman showed that nationwide, out of 742 stations monitored, 39 or only 5.3% were still in excellent condition (75-100% live coral cover), 187 or 25.2% could be considered in good condition (50-74% live coral cover), 290 or 39.0% were in fair condition (25-49.9% live coral cover), while the rest, 226 stations or 30.5% were in poor condition (0-24% live coral cover). Coral reefs are crucial in protecting coastal towns from erosion and storm damage. Their decline can also lead to decreased fish populations and threaten the livelihoods of many people who rely on fishing for their income. The tourism sector relies heavily on coral reef activities such as snorkeling and diving, and the decline of reefs can deter tourists and cause economic losses for coastal towns. Coral bleaching, a process caused by rising sea temperatures, makes coral prone to disease and upsets the delicate balance of the ecosystems (Eakin et al., 2004). As coral habitats decline, traditional practices are disrupted, and cultural identities are destroyed



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The patterns and trends discovered in the data will drive policy and conservation actions to protect coral reefs and the communities that rely on them for their livelihoods. The study aims to promote sustainable management and preservation of coral reef ecosystems for future generations.

The objectives of this paper are the following:

1. To explore the specific effects of overfishing on marine ecosystems in the Philippines
2. To investigate the causes and effects of pollution in Philippine waters
3. To understand how rising sea temperatures, ocean acidity, and extreme weather events associated with climate change are impacting coral reefs in the Philippines
4. Explore the qualitative evidence regarding the value of coral reefs to local populations.

## METHODOLOGY

The methodology section is an integral part of the study, which aims to provide a systematic process for investigating the different variables driving coral reef decline in the Philippines. It employs statistical analysis of secondary data in a qualitative approach.

The researchers conducted a comprehensive examination of existing secondary resources, including reports and datasets concerning coral reef degradation in the Philippines, the factors contributing to this decline, its effects on marine environments, the consequences for biodiversity preservation, and the qualitative evidence regarding the value of coral reefs to local communities. The researchers reviewed the collected data from pre-existing studies. This approach helped gain insights and identify the specific effects of overfishing on marine ecosystems in the Philippines, the cause and effects of pollution, and the effects of climate change, ocean acidification, and rising sea temperature from secondary sources collected from articles, publications, and news reports from the internet. The literature review of collected sources ensured the validity of all the data examined to reach the study's main purpose. These qualitative findings provide a holistic view of coral reef decline, its drivers, the implications on Philippine Biodiversity, and recommended steps for preserving coral reefs. By employing this methodology, the researchers aimed to contribute valuable insights into the complex dynamics of coral reef decline, fostering a deeper understanding of its drivers, impacts, and implications for the diverse marine ecosystems in the Philippines through qualitative insights, which provided depth and context, capturing the human and cultural dimensions helped understand and identify the broader implications, cultural dimensions, and human aspects associated with coral reef decline in the Philippines.

In summary, the researchers investigated coral reef degradation in the Philippines, analyzing factors such as overfishing, pollution, and climate change. The researchers utilized a wide range of secondary resources, including reports, datasets, articles, and news reports, to gather qualitative evidence on the value of coral reefs to local communities. By synthesizing this information, the researchers aimed to understand the specific effects of these factors on marine ecosystems and biodiversity preservation in the Philippines. Through the comprehensive literature review, the researchers ensured the validity of the data examined, providing a solid foundation for their qualitative findings. Ultimately, this study aimed to offer a holistic understanding of coral reef decline, its drivers, and implications for Philippine biodiversity while highlighting the broader human and cultural dimensions associated with this issue.

## RESULTS AND DISCUSSION

Coral reefs are the coastal ecosystem that provides the most substantial and sustainable source of sustenance to people in the Philippines (White, 1987; Alcala, 1988; McAllister, 1988; Gomez et al., 1994; White & Cruz-Trinidad, 1998). The country's 18000 km (about 11184.68 mi) coastline is estimated to have about 27000 km (about 16777.02 mi) of fringing reefs or submerged offshore reefs or coral atolls. This area is equal to slightly more than 10% of the country's total land area (Gomez et al., 1994). The Philippines is one of the world's 18 mega-biodiverse countries — the archipelago contains two-thirds of the earth's biodiversity and between 70% and 80% of the world's plant and animal species. It is home to 505 coral species and 915 reef fish species. The country is the world's third most coral-rich area after Indonesia and Australia," according to the Convention on Biological Diversity



(bworldonline.com, June 29, 2018). A preliminary study on the condition of corals in the Philippines by the Department of Science and Technology (DOST) showed that 90 percent of 166 reefs sampled are in poor or fair condition.

**A. *The specific effects of overfishing on marine ecosystems in the Philippines.***

It has long been known that overfishing plays a significant role in the declining state of coral reefs. The sensitive balance of reef ecosystems is upset by destructive fishing methods like blast and cyanide fishing, which also lead to the loss of coral cover. These actions damage the structure of coral reefs and reduce fish populations, which lowers biodiversity—enforcing rules and regulations into practice sustainable fishing techniques to avoid the decline of coral reefs. Overfishing and damaging fishing methods lead to coral reef loss by disturbing the ecosystem's fragile equilibrium. Overfishing is a stressor that negatively impacts ocean health indices such as biodiversity, food security, coastal livelihoods, and economies (Halpern et al., 2012). Overfishing has harmed the environment and the economy, declining coral reefs and other significant habitats. Important fish species have vanished, upsetting the fragile food chain and causing ecological imbalances that may take years to correct. The Philippines' predicament is expected to feel worse without prompt action and sustainable management techniques, endangering the health of the marine ecosystems and the welfare of the local populace. A study by Paula et al. (2014) claims that fish populations in the Philippines have declined because of overfishing, upsetting the declining balance of marine ecosystems. As a result, the area has less biodiversity and more invasive species. In addition, local fishing communities have suffered from the loss of specific fish species, which has resulted in financial difficulties and food shortages (Green et al., 2018). In general, the Philippines' overfishing has had a significant negative impact on marine ecosystems and the people who depend on them for their livelihoods.

**B. *The causes and effects of pollution in Philippine waters.***

The main sources of pollution in the Philippine seas are improper waste disposal, runoff from agriculture, and industrial waste. These pollutants all negatively impact the health of humans, ecosystems, and marine life. According to research from the University of the Philippines Marine Science Institute, fish populations and coral reefs have declined because of hazardous chemicals and heavy metals found in Philippine waters. Furthermore, pollution has been connected to increased respiratory issues and waterborne illnesses in coastal populations (UPMS, 2019). Stricter laws, environmentally friendly waste management techniques, and community involvement in conservation initiatives should be the main goals of any endeavor to combat pollution in Philippine waters.

Furthermore, it is essential to raise public awareness and provide education regarding the negative effects of pollution on ecosystems and human health. To fully comprehend the level of pollution in Philippine waters and how it affects marine life, monitoring and research must continue. The health of our seas and coastal towns will depend on implementing efficient pollution reduction initiatives, such as encouraging eco-friendly alternatives and enforcing penalties for violators. Securing a healthy environment between government agencies, non-profits, and local stakeholders will be essential to its implementation and enforcement. Garcia (2019) added that with the Philippines being the third largest contributor in the world to ocean pollution, the country is surrounded by islands of garbage that have piled up for years. This garbage tears up the coral skins, which invites infections, pathogens, and diseases to enter. Once coral reefs lose tissue due to coral disease, the tissue cannot grow back, and the disease will only keep proliferating.

**C. *Rising sea temperatures, ocean acidity, and extreme weather events associated with climate change impact coral reefs in the Philippines.***

The biggest threat to coral reef ecosystems worldwide is climate change, which impacts them through rising sea levels, modifications to the frequency and severity of tropical storms, and altered ocean circulation patterns. Increased greenhouse gas concentrations lead to the ocean's sea surface temperature rising and making the oceans more acidic, increasing the risks of coral bleaching, leading to coral death, and losing critical habitats for other species (Alcantara, 2023). As global temperatures rise, sea levels are also increasing, threatening the low-lying coastal areas of the Philippines: coastal erosion, saltwater intrusion, and the loss of valuable coastal habitats. Rising sea temperatures lead to coral bleaching, a process in which corals expel their symbiotic algae, causing them to turn white and become more susceptible to disease and death. The warming of ocean temperatures due to climate change severely threatens the Philippines' vibrant coral reefs. Increased carbon dioxide absorption by oceans results in ocean acidification, which inhibits the growth of coral reefs and other marine organisms with calcium carbonate shells. (Pabellano, September 2023). According to Global Coral Bleaching.org (2015), mass bleaching occurs when entire reef systems, not just



individual corals, turn white. The National Oceanic and Atmospheric Administration's (NOAA) Coral Reef Watch recorded an event in 1997-1998, killing 16% of the world's coral reefs. In 2010, WWF reported a mass bleaching in the Coral Triangle, where 76% of the Earth's known coral species can be found. The destruction of reefs was seen in Batangas and Palawan in the Philippines, Tioman and Redang in Malaysia, Aceh and Bali in Indonesia, and other areas. This is a dreadful situation for a country part of the Coral Triangle. This marine area holds 76 percent of the world's coral species – the highest coral diversity (Oceana, 2020) as ocean acidification can cause a mass extinction of marine species, food insecurity, and economic damage. Greenpeace (2013) notes that experts have long noted that the Philippine seas are set to suffer from the impacts of climate change, such as rising sea levels, increase in sea temperature, and more frequent and extreme weather. Communities, particularly those relying heavily on coastal resources, such as the Philippines, will bear the brunt of the impacts.

#### *D. Qualitative evidence regarding the value of coral reefs to local populations.*

Coral reefs are among the most diverse and productive marine ecosystems, providing many coastal protection functions and services. In the Philippines, coral reefs are substantially valued for their food security benefits. Coral reefs provide the spawning and nursery grounds that economically important fish populations need to thrive. They comprise about 10% of the protein intake per Filipino, 8–20% of the total fish harvest, and as much as 70% of the total fish catch in numerous small islands across the country. Coral reefs provide multiple ecosystem services that contribute indirectly to the food and livelihood security of coastal communities in the Philippines (Cabral, 2018). Coral reefs provide millions of jobs to locals through tourism, fishing, and recreational activities. Local communities along the coastal areas, particularly those with lower income levels, depend on coral reefs as an important source of employment, income, and tourism revenues. Coral reefs act as natural breakwaters that shield against coastal erosion, protecting villages near shorelines from strong waves' impact. Coral reef-based tourism, such as diving and snorkeling, is a substantial economic sector in the Philippines and Indonesia, supporting the livelihoods of several coastal communities through hotel services, boat rides, and tour guides (Cabral, 2018). Coral reefs help to protect coastal communities from storm surges and erosion from waves, both of which are likely to increase in the face of sea-level rise. These coral habitats form natural barriers that protect nearby shorelines from the eroding forces of the sea, thereby protecting coastal dwellings, agricultural land, and beaches. More than 150,000 km (about 93205.68 mi) of shoreline in 100 countries and territories receive some protection from reefs.

## DISCUSSION

The results of this study imply that by implementing stricter regulations controlling fishing methods, reducing pollution, and creating marine protected zones, policymakers might effectively offset the disappearing coral reefs in the Philippines' biodiversity. These findings provide economic reasons for managing coral reefs and the habitats and fisheries they support. The reduction of reefs in the Philippines results in economic and quality-of-life losses for people, communities, and society. Coral reefs generate significant revenue for the global economy, play an important role in medical research, and support over 25% of all marine species. The global decline of coral reefs is not new: it has occurred in the past due to natural causes.

Nonetheless, humans have significantly impacted water pollution and coral reef degradation. The global disappearance of coral reefs demands an urgent reconsideration of present management techniques. Many researchers have concluded that coral reefs need immediate protection. Coral reefs require additional research for recovery because natural forces are difficult to manage. When we focus on recovery rather than prevention, prevention can also be found in human behavior, another significant issue to address through special programs.

## IMPLICATIONS

The study highlighted the risks and consequences of the loss of coral reefs on the biodiversity of the Philippines. According to the study, fish populations have declined, different marine species have lost habitat, and the general health of the marine ecosystem has decreased because of the Philippines' declining coral reefs. The study also demonstrated how crucial it is to carry out conservation initiatives to safeguard and rebuild coral reefs to maintain the Philippines' abundant biodiversity. To guarantee the long-term well-being and survival of the marine ecosystems in the area, it also underlined the necessity of sustainable practices. The study concluded that the Philippine coral reefs are under threat and that immediate action is required to address this since a loss in these ecosystems might significantly impact the nation's marine biodiversity. The study also emphasizes the significance of



community engagement and education in advancing conservation initiatives and increasing public understanding of the importance of coral reefs.

## RECOMMENDATIONS

The decline of coral reefs in the Philippines is a complex and compelling case that requires a multifaceted approach to combat the rapid degradation of these coral centers of marine life activity, targeting the main drivers of the steady decline and establishing effective management of marine protected areas (MPAs) to support coral reef resilience, by conserving and restoring coral reef ecosystems promoting sustainable fishing practices and ensure harvest control measure by protecting important species from being overfished, implementing measures to reduce pollution from sedimentation and any land-based sources. Addressing local threats by having a network of marine protected areas and a well-implemented coastal resource management plan should help strengthen coral-rich habitats to be more resilient through mitigation strategies. Community involvement and education play a pivotal role alongside integrated coastal management approaches considering ecological and socio-economic aspects. Supporting research and monitoring efforts, advocating for policy support, and fostering international cooperation are also vital. Furthermore, providing alternative livelihood opportunities for communities dependent on coral reef resources can help alleviate pressure on reef ecosystems. By implementing these recommendations holistically and collaboratively, stakeholders can work towards preserving the long-term health and resilience of coral reefs in the Philippines.

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