

Quantify the Influence of Coral Reef Bleaching on Tourism in Small Island Developing States (SIDS)

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Abstract: As global climate change keeps deteriorating, adverse effects have emerged, including global warming, rising sea levels, and extreme weather. From diverse literature, we summarized that these effects have triggered irretrievable damage to coral reefs worldwide and indirectly influenced tourism in small island developing states (SIDS). Since the economy depends drastically on tourism, we propose the study to quantify the effect caused by coral bleaching, a by-product of global warming, on tourism in SIDS. We schedule to find the relationship between coral bleaching rate and tourism development in targeted areas via a panel data model and a regression model. We expect our result can contribute to part of the ministries' legislation in SIDS.

Keywords: dive tourism, coral bleaching, SIDS, regression analysis

1. Introduction

Climate change has widely been known as one of the long-term threats to coral reefs. Much research has examined ecological impacts, like severe tropical storms, sea level rise, sea surface temperature, and ocean acidification on coral reefs [1]. Meanwhile, the relationship between coral reefs and the world is bidirectional. Previous research has established how coral bleaching impacts fisheries and ecosystems. However, little is quantified about how coral reefs affect coastal tourism. The tourism section is fundamental to small islands' economy. For example, the tourism industry accounts for approximately 90 percent of Maldives' GDP and Fiji's foreign exchange earnings. This study investigates the effect of coral reefs on dive tourism, exemplifying dive tourism in small islands in developing states.

We expect to use regression analysis to analyze the data we collected to determine if there is any linear relation between our variables using R. Our independent variable is the damage to coral reefs. Our dependent variable is tourism in several small island developing states (SIDS). We chose the change in the number of coral reefs surrounding those SIDS and the number of tourists annually as our indicators.

For this research, we use two categories of data: coral reef data and diving industry data. For coral reef data, we focus on a global data set's SIDS data that lasts 40 years. We use the global dataset of PADI, a professional diving agency, and UNWTO for diving industry data.

Since tourism affects many other industries in SIDS, including employment, national image, and further economic development, our findings can guide those governments and related ministries to find a feasible solution against ongoing coral bleaching.

2. Literature review

2.1. The importance

Coral reefs are often called the 'rainforest of the sea,' which comprise only about 0.5 percent of the ocean floor but play a pivotal role in regulating global temperature and producing oxygen [2]. Moreover, due to their complex structure, coral reefs are also shelters for numerous creatures, providing food at all levels of the food chain. There are about four thousand species of fish throughout reef ecosystems. Because of the multiple crannies and nooks that reef structures offer fish, they may hide from predators, discover food sources, reproduce, and raise young.

2.2. The threat

Corals are struggling to survive. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change showed that human activity dramatically caused global warming, from deforestation to burning fossil fuels. The warming temperature leads to the rising sea temperature, giving rise to a severe relationship between corals and their symbiotic zooxanthellae and then making corals lose their color and weaken. Another indicator of climate change is Ocean acidification. Oceanic uptake of CO₂ leads to the lower pH and lower saturation states of the carbonate minerals calcite, aragonite, and high-magnesium calcite, the constituents used to form supporting skeletal structures in the carbonate system of coral reefs [3].

Coral reef decline is a worldwide concern, not just for the organisms whose habitats depend on them and the distinctive ecosystem tasks they carry out but also for the local populations that depend on these reefs for their subsistence. However, it takes thousands of years for reefs to mature. The research found that Global coverage of living coral has decreased by 50% since the 1950s. At least 63% of coral-reef-associated biodiversity has declined due to the loss of coral extent [4]. With the degradation of coral reefs, the well-being and sustainable coastal development of human activities, which rely on coral reef ecosystem services, are in great danger. A growing number of studies recognize how natural factors impact reefs. However, what kind of human activities may threaten reefs has not received comprehensive attention.

2.3. The impact

2.3.1. Coral reefs

Significantly enhancing the fishing are coral reefs. About six million people rely on coral reef fisheries for their livelihood, most of whom live in underdeveloped nations. According to some estimates, reef fisheries makeup about 25% of all fish catches in developing countries. Research has been done on the effects of coral reefs on households that depend on fishing and has offered helpful advice to the authorities [5].

Meanwhile, reefs control the shoreline positioning drastically. Evidence shows that coral reefs play a protective role in shorelines on wave propagation patterns [6]. Reef degradation is correlated with severe coastal erosion to some extent. Coral reefs are the first line of resisting erosion and flooding through wave attenuation and holding sand [7]. The direct causality between reefs and shoreline stability has been demonstrated [8]. The existing body of research on coral reefs suggests that reefs can hardly be ignored if humans want sustainable development.

2.3.2. dive tourism

Small islands grow as a result of dive tourism. According to the findings, the combined economies of Indonesia and the Philippines generate more than USD 150 million annually from muck diving tourism. More than 2200 people are employed there, and over 100,000 divers are fascinated by it each year [9]. This sector offers the facilities and services needed to make the activity possible. Customers visit a dive shop to buy scuba diving accessories like snorkels, masks, fins, dive boots, or neoprene socks. It might encourage the growth of nearby industrial areas. Service industries like training and chartering can also experience rapid growth.

Dive tourism is detrimental to coral reefs even though it is essential in tiny island developing states. Studies over the previous three decades have uncovered crucial facts about human influence. Divers can harm reefs by touching them [10], using cameras [11], and moving their fins [12].

3. Contribution

Studies have shown the upsides and downsides of the dive business, and coral reefs may also impact dive tourism. There isn't much literature in this area, and coral reefs' direct impact on the dive business also warrants careful consideration.

To determine the connection between coral reefs and diving tourism, we attempt to construct a panel data model and a simple linear regression model in this publication. Using the global coral-bleaching database, 1980-2020, we are committed to discovering this regulation and offering a resource for other academics and decision-makers. This study's very straightforward models and broad conclusions are its main weaknesses. Additionally, we only concentrate on islands in developing nations. More detailed models and more general topics may be explored in future studies.

4. Conceptual framework

4.1. Coral bleaching

Coral reef bleaching is a spatial and temporal pattern, an ecologically and economically important consequence of climate warming [13]. It is a phenomenon that occurs when a coral reef loses its vibrant color and turns white or pale due to stress. This is a significant concern as it can result in the degradation of coral reefs, an essential ecosystem that provides habitat for numerous marine creatures and protects coastlines from erosion.

4.2. Coastal tourism industry

Coastal tourism refers to traveling to coastal areas for recreational activities and enjoying the natural beauty of the sea, beaches, and coastal landscapes. Coastal tourism plays an integral part in the economy of many regions. It operates income for local businesses, including restaurants, hotels, tour operators, and souvenir shops. It also provides employment opportunities for residents in these regions.

4.3. Small island developing states

Small island developing states (SIDS) are countries characterized by their small sizes, limited natural resources, and vulnerability to environmental and economic challenges. These states are typically in the Caribbean, Pacific, and Indian Ocean regions. SIDS are particularly vulnerable to the impacts of climate change, such as rising sea levels, increased frequency and intensity of natural disasters, and coastal erosion. These states often lack the necessary infrastructure and resources to adapt to and mitigate these effects.

4.4. Climate change and coral bleaching

Coral bleaching is typically caused by environmental factors, such as unusually high water temperatures, pollution, or changes in water chemistry. When corals become stressed, they expel the algae living inside them, which gives them their color and provides them with energy through photosynthesis. Without these algae, the corals become weakened and more susceptible to disease, which can ultimately lead to their death.

4.5. Coral bleaching and scuba-diving

Scuba diving can provide an opportunity to witness and understand the impact of coral bleaching firsthand. If coral reef continues to deteriorate, tourists' demand for scuba diving will decrease.

5. Data Section

The data for this research is derived from two primary datasets [14]: coral bleaching data and diving industry data from Small Island Developing States (SIDS). The utilization of these datasets will provide valuable insights into the relationship between coral bleaching events and their impact on the diving industry in SIDS.

5.1. Coral Bleaching Data

We will utilize the Global Coral-Bleaching Database (GCBD) from 1980 to 2020, containing 34,846 records from 14,405 sites in 93 countries, including a substantial representation of SIDS. This extensive dataset allows for a comprehensive analysis of trends and patterns across different regions and timeframes. Additionally, by comparing data between SIDS and other developing countries, we can better understand the varying occurrences of coral bleaching.

The four-decade-spanning history of the GCBD enables a thorough understanding of the evolution of coral bleaching and potential changes in the frequency and intensity of thermal stress events. We will correlate specific years with drastic changes in particular locations to identify causal factors influencing these events. Furthermore, the GCBD's inclusion of critical environmental variables, such as site exposure, distance to land, mean turbidity, cyclone frequency, and sea-surface temperature metrics, allows us to investigate potential drivers influencing coral bleaching events.

5.2. Data Analysis for Coral Bleaching

We will conduct a comprehensive temporal analysis of SIDS data to identify trends and changes in coral bleaching occurrences. This analysis will enable us to determine whether there has been an increase in the frequency and intensity of thermal stress events affecting coral reefs globally.

We will employ geospatial analysis and generate maps based on the GCBD for spatial understanding. This approach will help us identify hotspots of coral bleaching and assess the vulnerability of specific locations, focusing on SIDS. Moreover, by comparing coral bleaching occurrences across different countries and regions and detailed site characteristics, we will explore how local factors influence coral health and susceptibility to bleaching, thus highlighting the unique challenges SIDS faces in preserving their coral ecosystems.

5.3. Diving Industry Data

As a reliable source of diving industry data, we will use information from the Professional Association of Diving Instructors (PADI), one of the largest and most reputable scuba diving agencies globally. The PADI dataset covers scuba diving tourism statistics, including the growth of scuba

diving, European diver statistics, female diver statistics, and dive destination statistics over 16 years. PADI operates in 189 countries, providing data representing a broad global perspective, allowing us to gain insights into scuba diving trends and patterns, particularly within SIDS.

5.4. Data Analysis for the Diving Industry

We will integrate PADI's diving industry data with the coral bleaching data to investigate potential correlations between coral bleaching events and the diving industry's performance in SIDS. Conducting trend analysis, we will assess changes in the number of divers and the industry's growth rate over time, considering the possible influence of coral bleaching on these factors.

To understand if certain groups of divers are more susceptible to the impact of coral bleaching, we will utilize female diver statistics and explore age group certifications to assess the participation of different age cohorts in scuba diving. This analysis will allow us to gauge how coral bleaching might affect the divers' demographics and inform measures to foster sustainable diving practices in SIDS.

6. Empirical approach, methods

The primary purpose of the empirical analysis is to determine the impact of coral bleaching on tourism development in small island developing states (SIDS) around the world from 1980 to 2020. The whole analysis will depend on conceptual modeling. We decide to use the panel data model based on the potential data we might use.

To measure the bleaching process, we decided to gauge the initial coral reef area surrounding our targeted islands first. Then we collect annual data of the bleaching proportion of coral reefs to calculate the bleaching rate, and this process is partly done by Robert van Woesik and Chelsey Kratochwill [14].

We obtain data from each island's national bureau of statistics to measure tourism development. One of our indicators is the passenger flow of local airports, or to be specific if we can, it can be the total number of scuba divers at each site since the scuba diving industry makes up an overwhelming part of these islands' tourism. The other indicator is the revenue from tourism or the scuba diving industry. In the alternative, we will use the payment of the local tertiary industry to replace tourism revenue because in some SIDS tourism accounts for up to 70% of the local economy.

This conceptual function is thus used for the research:

$$TOURISM = f(CRB)$$

TOURISM is the total tourist arrival data in SIDS obtained from the local statistics bureau, measuring tourism development. We plan to conduct 2 groups of experiments: one is tourism revenue and the other is tourist flow at the local airport.

CRB is the coral bleaching rate obtained from Robert van Woesik and Chelsey Kratochwill 2022 essay.

Then we plan to use OLS linear regression to estimate the parameters:

$$Y = \beta x + \varepsilon$$

β represents parameter estimates, and ε represents the random disturbance term.

7. Conclusion

The comprehensive analysis of coral bleaching data and diving industry data from SIDS will provide valuable insights into the impact of coral bleaching on the diving industry in Small Island Developing States. By integrating these datasets, we will identify potential correlations and trends, empowering us to address challenges, formulate effective conservation strategies, and ensure the sustainable development of diving tourism in these regions.

Meanwhile, we chose only 5 SIDS as our research object. Since there are still many SIDS in today's society, if anybody can take more SIDS into account, the research result may be more accurate and reliable. The result can represent the economic situation suffered by many SIDS; thus, governments and other related ministries can apply it to their legislation.

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