

Adaptation To Cope With The Phenomenon Of Coral Reefs Bleaching For Carrying Out Sustainable Tourism

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ABSTRACT

The tourism sector is very sensitive to climate change. Especially for the tourism sector in Indonesia which relies heavily on natural resources and biodiversity, both in the waters or sea and mountains. The impact of climate change on the tourism sector can be immediately seen. Based on the background description above, this article will elaborate an overview of the influence of climate change and the potential impact on coral reef bleaching and its consequences on the tourism sector that may occur in Indonesia. This study aims to obtain the general portrait regarding the coral reef which may be affected by the climate change and the adaptation effort for oceanique tourism in Indonesia. The study uses a qualitative approach using library search. Supporting data and information were obtained from various literature in the form of books, reports, journals, magazines and relevant internet sites. Data is presented in the form of a narrative description and analyzed descriptively in accordance with the research objectives. The adaptation effort are (1) Maintain the health of the underwater ecosystem, (2) Involving Tourists in Bleaching Issues, (3) Diversify the tourism industry, (4) Reducing the Impact of Tourism Activities in General, (5) Encourage tourists to contribute funds to recovery and management efforts, (6) Disseminate Information to the Public Through Education and Other Propaganda. Meanwhile, for institutional capacity, adaptations can be made as follows: (1) Institutional Strengthening, (2) Community-Based and Collaborative Management, (3) Public Awareness, Education and Extensification.

Keywords : climate change, coral reef, adaptation

ABSTRAK

Sektor pariwisata sangat sensitif terhadap perubahan iklim. Sektor pariwisata di Indonesia yang sangat bergantung pada sumber daya alam dan keanekaragaman hayati, baik yang berada di perairan atau laut maupun pegunungan. Dampak perubahan iklim terhadap sektor pariwisata bisa langsung terlihat. Berdasarkan uraian, artikel ini akan menguraikan gambaran pengaruh perubahan iklim dan potensi dampak pemutihan terumbu karang serta dampaknya terhadap sektor pariwisata yang mungkin terjadi di Indonesia. Penelitian ini bertujuan untuk memperoleh gambaran umum mengenai terumbu karang yang mungkin terkena dampak perubahan iklim dan upaya adaptasi wisata kelautan di Indonesia. Pendekatan yang digunakan kualitatif deskriptif dan metode pencarian perpustakaan. Data dan informasi pendukung dari berbagai literatur berupa buku, laporan, jurnal, majalah dan situs internet. Adaptasi untuk menghadapi isu pemutihan terumbu karang yaitu (1) Menjaga kesehatan ekosistem bawah laut, (2) Melibatkan Wisatawan dalam Isu Pemutihan, (3) Diversifikasi industri pariwisata, (4) Mengurangi Dampak Kegiatan Pariwisata Secara Umum, (5) Mendorong wisatawan menyumbangkan dana untuk pemulihan dan upaya pengelolaannya, (6) Menyebarkan Informasi kepada Masyarakat Melalui Edukasi dan Propaganda Lainnya. Kapasitas kelembagaan: (1) Penguatan Kelembagaan, (2) Pengelolaan Berbasis Masyarakat dan Kolaboratif, (3) Penayadaran, Edukasi dan Ekstensifikasi Masyarakat.

Kata Kunci: Perubahan Iklim, Terumbu Karang, Adaptation

INTRODUCTION

Background of the research

The tourism sector is very sensitive to climate change. Especially for the tourism sector in Indonesia which relies heavily on natural resources and biodiversity, both in the waters or sea and mountains. The impact of climate change on the tourism sector can be immediately seen, for example, increasing sea wave heights which pollute the availability of clean water and threaten the existence of small islands, increasing sea water temperatures which damage coral reefs which are tourist attractions, or high rainfall which changes the seasons and prevents diving or mountain climbing (Scott et al., 2012; Siddiqui & Imran, 2018).

Meanwhile, tourists' demands for a tourism process are comfort, security and satisfaction because they have succeeded in reaching their desired tourist destination. When it is predicted that a tourist trip will be uncomfortable, unsafe, and difficult to reach the tourist destination he hopes for, he will immediately make a decision to change his tourist destination to another place or country that is thought to meet his expectations. In fact, one of the sources of the Indonesian economy is through the tourism sector (Gnanapala, 2015; Maricar & Glen, 2021; Vengesai et al., 2009).

Indonesia is an archipelagic country in Southeast Asia which has 17,504 large and small islands, and around 6,000 of them are uninhabited, which are spread around the equator which provides tropical weather. Indonesia is located at the heart of the Coral Triangle, a region that is home to the richest marine biodiversity on earth. Indonesia is famous for its ecosystem diversity its coast, which contains 18 percent reef world corals, more than 70 genera and 500 species of coral, 2,500 species of fish, 2,500 species of molluscs, 1,500 species crustaceans, and various other marine biota (Setiawan, 2013). However, Indonesia is indeed vulnerable to global climate change. Moreover, many studies on climate change say that during the 20th century the global climate changed on average by around 0.6 degrees Celsius per year. Apart from the projected sea level rise in Indonesian waters, sea water temperatures will also definitely increase (Gaora et al., 2023; Triana & Wahyudi, 2020).

Global warming which causes sea water temperatures to rise is also one of the causes of damage to coral reefs in the form of coral bleaching. Coral reefs can be restored naturally. However, this process takes a long time to return to normal. Meanwhile, the continuous increase in sea water temperature causes coral reef bleaching to continue and ultimately the coral reefs cannot survive and eventually die (Gaora et al., 2023; Nurlatifah et al., 2021; Susanto et al., 2015; Triana & Wahyudi, 2020).

In fact, the gem of Indonesian tourism that lies at the tip of the spear is underwater tourism, with the beauty of coral reefs in underwater national parks spread throughout Indonesia. Several tourism destinations which have rich coral reef among others Raja Ampat, Bangka Belitung, Wakatobi and so on. Therefore, it is critical matter that Indonesia to cope and adapt to the phenomenon of global climate change. Of course, coral reefs, which are the queen of Indonesian tourism, will be on the brink of destruction. The result is certain to be the loss of sources of income and livelihood for some Indonesian people (Kusumasari, 2016; Rachmawati et al., 2022).

Based on survey in 2019, the condition of coral reefs in Indonesia was varied. Around 33.8% coral reefs were insufficient, 37.4% were in fair condition, 22.4% were good, and 6.4% were excellent (Setiawan, 2013). Even the total coral reefs is around 2.5 million hectar with 569 species, there are threats to the existence of the health coral reefs such as blast fishing, bleaching and sedimentation (Lyons et al., 2024).

Formulation of the problems

Based on the background description above, this article will elaborate an overview of the influence of climate change and the potential impact on coral reef bleaching and its consequences on the tourism sector that may occur in Indonesia

Research aim

This study aims to obtain the general portrait regarding the coral reef which may be affected

by the climate change and the adaptation effort for oceanique tourism in Indonesia.

METHODOLOGY

The research was carried out using the method library search. Supporting data and information were obtained from various literature in the form of books, reports, journals, magazines and relevant internet sites. Data is presented in the form of a narrative description and analyzed descriptively in accordance with the research objectives.

RESULT AND DISCUSSION

Climate change, global warming and its impact

Global climate change as an implication of global warming has resulted in atmospheric instability in the lower layers, especially those close to the earth's surface. Global warming is caused by an increase in greenhouse gases, which are predominantly caused by industry. This increase in greenhouse gases causes the effect of reflection and absorption of long heat waves (infrared) emitted by the earth's surface back to the earth's surface. Observations of global temperatures since the 19th century have shown changes in average temperatures which are indicators of climate change. This change in global temperature is shown by an increase in the average temperature of up to 0.74oC between 1906 and 2005. This global average temperature is projected to continue to increase by around 1.8°-4.0°C in the current century, and according to other studies in the IPCC it is even projected ranges from 1.1-6.4°C (Pendleton et al., 2016).

Besides that, global warming is also predicted to increase the intensity and frequency of extreme climate events such as long droughts and extreme high rainfall which can cause flooding problems. Related to this, climate change and environmental degradation and their impacts are no longer an issue, in fact in the future the escalation will occur more quickly, so that it will have a negative impact on all sectors (Kinzler et al., 2023).

Changes in average annual rainfall and temperature in Indonesia cause changes in seasons. The rainy season will arrive later but shorter, but with more intense rainfall and increasing the risk of flooding. It is estimated that by 2080 parts of the islands of Sumatra and Kalimantan will be 10-30% wetter in the rainy season, while the islands of Java and Bali will be 15% drier (Case et al., 2007)

In most areas in Sumatra during the period 1960-1990 and 1991-2003, the start of the rainy season is now 10 to 20 days late and the start of the dry season is 10 to 60 days late. Various similar shifts have also been felt on the island of Java. These patterns have the opportunity to continue. In the future, parts of Indonesia, especially areas located south of the equator, may experience a longer dry season and a shorter rainy season but with higher rainfall with the type of change in pattern as described below. In addition, the climate is also likely to become more changeable, with increasingly frequent and erratic rainfall. Higher temperatures can also dry out soil, reduce groundwater resources, degrade land, and in some cases can lead to desertification (Kinzler et al., 2023).

Impact in the form of coral reefs whitening

Coral reefs are one of the marine and coastal ecosystems, alongside seagrass beds and mangrove forests. Coral reefs grow in shallow sea waters, with clear water and warm temperatures of more than 20° C. Coral reefs are a very rich form of biodiversity where 3000 species of flora and fauna live on them. Coral reefs are a home for small fish and a place for them to find food. Indonesia as a maritime country has 17,000 islands with a coastline of around 81,000 square km, and is a coral triangle country in the world. This region includes Indonesia, the Philippines, Malaysia, Timor Leste, Papua New Guinea and the Salomon Islands. The total area of coral reefs in the Coral Triangle is around 75,000 km².

Indonesia has beautiful coral reefs with 450 types of coral and 15 percent of the world's coral reefs are in Indonesia. According to the Oceanography Center of the Indonesian Institute of Sciences (LIPI), based on research by LIPI and the National Aeronautics Institute (LAPAN), Indonesia has coral reefs covering an area of 19,500 km². Indeed, there are studies that say it reaches 85,000 Km², but LIPI and LAPAN's calculation is only 19,500 Km². Currently, the Raja Ampat Islands in West

Papua are the islands with the highest number of coral reef types in the world. Based on an ecological study led by The Nature Conservancy (TNC) involving world coral reef and fish experts in 2002, around 537 types of coral and 1074 types of fish were found in the Raja Ampat islands.

Coral reefs are actually a collection of small animals, namely polyps, which gather and form coral reefs. Coral reefs grow and develop because they are able to catch their food in the form of plankton through their tentacles. Apart from that, coral reefs also live in symbiosis with small algae, namely Zooxanthellae, which live on coral reefs. Zooxanthellae provide 95% of the energy, nutrients and carbon produced by photosynthesis to coral reefs, as well as providing color to coral reefs. Meanwhile, coral reefs also provide important nutrients to Zooxanthellae. From this process, colonies are then formed which form a limestone or calcium carbonate framework (Pasternak, 2012).

Coral reef ecosystems are the most productive ecosystems and their rich biodiversity is often compared to the biodiversity of tropical rain forests. Apart from that, coral reefs also function as providers of food and shelter for marine biota, as protection areas for coastal areas, and can also be a basic ingredient for medicine.

On the other hand, the coral reef ecosystem is the ecosystem whose sustainability is most threatened. Most coral reef ecosystems are in tropical waters and are very sensitive to changes in their living environment. There are many causes of coral reef damage. In general, the causes of coral reef bleaching are: abnormally high sea water temperatures, high levels of ultraviolet light, lack of light, high levels of turbidity, water sedimentation, abnormal salt levels and pollution, coastal development, coral reef disease, overfishing and also the phenomenon of global warming, especially increases in temperature, salinity and sedimentation. The following is a brief description of the causes of coral reef bleaching.

Changes in Sea Level

As an archipelagic country, Indonesia is most vulnerable to sea level rise. Sea level rise projections have been carried out for Indonesia, until 2100, it is estimated that there will be a sea level rise of up to 1.1 m which will result in the loss of coastal areas and small islands covering an area of 90,260 km². Meanwhile, climate change as an implication of global warming, which is caused by an increase in greenhouse gases, especially carbon dioxide (CO₂) and methane (CH₄), results in two main things happening in the lowest layers of the atmosphere, namely high fluctuations in rainfall and an increase in sea face. Rising sea levels can harm coral reef species that only grow in shallow waters. Some coral reef species may not be able to grow quickly (decreasing calcification rates) to compensate for rising sea levels and will slowly “sink”. The combined impact of high Sea Surface Temperatures and high levels of sunlight (at ultraviolet wavelengths) can accelerate the bleaching process by overpowering coral's natural mechanisms to protect itself from excessive sunlight (Pasternak, 2012).

Changes in sea surface temperature

Climate change causes disruption to ecosystems. Due to the warming weather, many types of living creatures cannot survive and are threatened with extinction. Coral reefs will also experience a bleaching process, and will be damaged and lose their color and attractiveness. If continuously exposed to rising sea surface temperatures, coral reefs are threatened with death.

The increase in sea water temperatures, especially during El Niño 1997, has caused serious problems in coral reef ecosystems. Wetlands International (Burke et al., 2002) reported that El Niño that year had destroyed around 18% of coral reef ecosystems in Southeast Asia. Coral bleaching has occurred in many places such as the eastern part of Sumatra, Java, Bali and Lombok. In the Seribu Islands, around 90-95% of coral reefs at a depth of 25 m have partially experienced bleaching (Setiawan, 2013)

Massive coral bleaching of around 20% of the world's coral reef population over the last two decades is the result of increasing sea surface temperatures, especially in hotspots. Hotspots are areas where the sea surface temperature exceeds the annual estimate of 1^o C. If the hotspot is above the annual maximum temperature for more than ten weeks, then coral reefs will be exposed to bleaching. In this condition, Zooxanthellae are unable to photosynthesize and produce food or nutrients, and lose their ability to provide color. Meanwhile, coral reefs can only live in shallow areas, with clear water

and warm temperatures.

When there was a change in environmental temperature due to global warming that hit tropical waters in 1998, it caused coral bleaching which was followed by mass deaths reaching 90-95%. During this bleaching event, the average surface water temperature in Indonesian waters was 2-3°C above normal temperature. (Wikipedia). In fact, the limit for the maximum increase in sea surface temperature that can still be tolerated by coral reefs is only 2° C.

NOAA satellite data on warming ocean temperatures shows that coral bleaching is occurring in all regions and is becoming more frequent. Extreme disturbance will kill coral reefs because corals cannot survive without the food provided by algae or Zooxanthellae. Even less intense bleaching can weaken corals, reduce their growth and reproductive capacity, and make them more susceptible to disease.

This impact is thought to repeat the impact of the El Nino Southern Oscillation (ENSO) event in 1997-1998. In 2002, the World Resource Institute stated that sea water temperatures which increased by 1-3°C at that time had triggered the largest coral reef bleaching event in history. Nearly 18% of coral reefs in Southeast Asia are damaged and destroyed. In Indonesia itself the coverage starts from the waters of Sumatra, Java, Bali to Lombok. There was death of 90-95% of coral reefs in the waters of the Seribu Islands and 2 years after the incident only 30% had recovered. El Nino that year also caused around 90% of the coral reefs in the Mentawai Islands to die. The coral reef ecosystem in Indonesian waters covering an area of 51,875km², which is equivalent to a third of the area of the island of Java, is threatened with permanent damage and destruction if global warming continues. This also means that the survival of various types of marine life that depend on this natural ecosystem is threatened. Damage to coral reefs also means the loss of natural protection for coastal areas which will trigger an increase in the rate of coastal erosion. The area of Indonesian coral reefs is estimated to range between 50,020 km² (Moosa et al., 1996 in KLH, 2002) to 85,000 km² (Dahuri 2002). Only about 6 percent of coral reefs are in very good condition, it is estimated that some of Indonesia's coral reefs will disappear in 10-20 years and others will disappear in 20-40 years. Damage to coral reefs has an impact on coastal communities, for example reducing the livelihoods of small fishermen.

Increased sea water acidity

Increasing CO₂ concentrations in the atmosphere will change ocean chemistry and have serious implications for coral reefs and other lime-producing organisms. According to AIMS (2005), around 30% of the CO₂ released into the atmosphere by various human activities since the Industrial Revolution is absorbed by the ocean. This phenomenon will change ocean chemistry, namely becoming more acidic (lower pH) and changing the concentration of carbonate and bicarbonate ions. Many organisms (corals, calcareous algae, mollusks, benthic organisms and plankton such as foraminifera and coccolithophora) that use calcium and bicarbonate ions from seawater to secrete limestone skeletons are affected by changes in ocean chemistry. These organisms will produce limestone skeletons that are not as good as in the pre-industrial era and ultimately produce skeletons that are brittle and grow more slowly. This weak reef structure will reduce its resilience to natural forces (erosion) and slower growth will reduce the rate of recovery after bleaching events and other natural disturbances.

The characteristic of damaged coral reefs is coral bleaching. Some coral bleaching phenomenes have already emerged in 10 locations in Asia Pacific namely in Bali Barat National Park (West Bali), Bunaken National Park, Cendrawasih National Park, Ujung Kulon National Park, Karimun Jawa National Park, Kepulauan Seribu National Park, Tubatana Filipina National Park, El Nido Filipina National Park, Phuket National Park Thailan and Kabara Island Fiji.

Adaptif and Participative Tourism Development

Adaptation ability

According to UNDP (2004) Adaptation is a process where strategies aimed at moderating, overcoming and gaining benefits that take the consequences of climate events are enhanced,

developed and implemented. Climate change has quite far-reaching implications for the tourism sector and tourist destinations. Therefore, knowledge and insight regarding adaptive capacity should be possessed and utilized by tourism actors in order to be able to face the challenges of climate change in the future, which is currently felt to be very lacking. However, it has been proven that it is not enough to rely on the past. Facing future climate change with different complexities and conditions that require further adaptation.

The capacity to adapt among components in the tourism value chain (sub-sectors of the tourism industry) varies greatly. For example tourists, tour operators and tourism service suppliers (airlines/trains/buses), travel agents (from the tourism sub-sector), and also hotels/resorts, attractions, operators and communities in tourist destination areas.

Tourists have the greatest adaptive capacity (depending on three main resources, money, knowledge and time) and are relatively free to avoid tourist destinations affected by climate change or shifts in travel times to avoid unfavorable climate conditions. While tour operators and tourism service suppliers (airlines/trains/buses), travel agents in certain tourist destinations lack adaptive capacity. Tour operators who do not have infrastructure are in a better position to adapt to changes in tourist destinations because they can respond to client or tourist requests and provide information about several travel destination options for clients. tour operators and tourism service suppliers (airlines/trains/buses), travel agents who invest large amounts of investment in mobile capital assets such as hotels/resorts, marinas and so on have the lowest adaptive capacity. The demand for information, policy changes and investment required for effective implementation of adaptation by tourism destinations will take decades to implement these adaptation programs. Therefore, fast action is needed for tourist destinations because the estimated impacts of climate change will arrive at their place, namely in 2050 (Singh et al., 2021).

Tourist	Tour operators, transport providers (railways, airlines, car), travel agents	Hotel/resorts, attraction operators, communities
I		
High	← Adaptive capacity →	Low

Figure. 1 Relative adaptive capacity of major tourism sub-sectors

Source: UNWTO-UNEP-WMO (2008)

Adaptation and mitigation can complement each other, substitute for each other or be independent of each other (Chen & Lackner, 2016). If complementary, then adaptation will reduce the costs of climate change impacts and thereby reduce the need for mitigation. Adaptation and mitigation are substituted to a certain point. But mitigation will always be necessary to avoid permanent changes to the climate system. Meanwhile adaptation will still be necessary because climate change is an irreversible phenomenon resulting from historic flows and rises in GHG and inertia in the climate system. All IPCC reports, and especially the 4 IPCC Assessment Reports. Climate change is already causing a setback in economic and social development in several developing countries with a temperature increase of less than 1 °C then climate change will continue increasing risks and costs substantially and therefore mitigation and adaptation strategies are urgently needed to limit the impact of climate change on the ability to achieve the UN Millennium Development Goals. Ideally, such tourism destinations, businesses and organizations should strive to address mitigation and adaptation simultaneously. The various adaptation frameworks identified above contain a number of common key elements that must be considered for any adaptation strategy summarize many common elements (Bruni et al., 2012; Füssel & Klein, 2004). While all the important elements are necessary, and the extent to which they are emphasized depends on the specific adaptation process and the stakeholders involved. Where climate change has been identified as a known risk, but little information exists to evaluate the type and severity of climate change impacts on the tourism sector (knowledge gap area identified by UNWTO-UNEP-PPL 2008), then large investments in information and science required knowledge.

In other countries and destination countries where the nature of climate change risks is well understood, the implementation of formal planning processes involving the allocation of tourism stakeholder responsibilities will be more focused and appropriate.

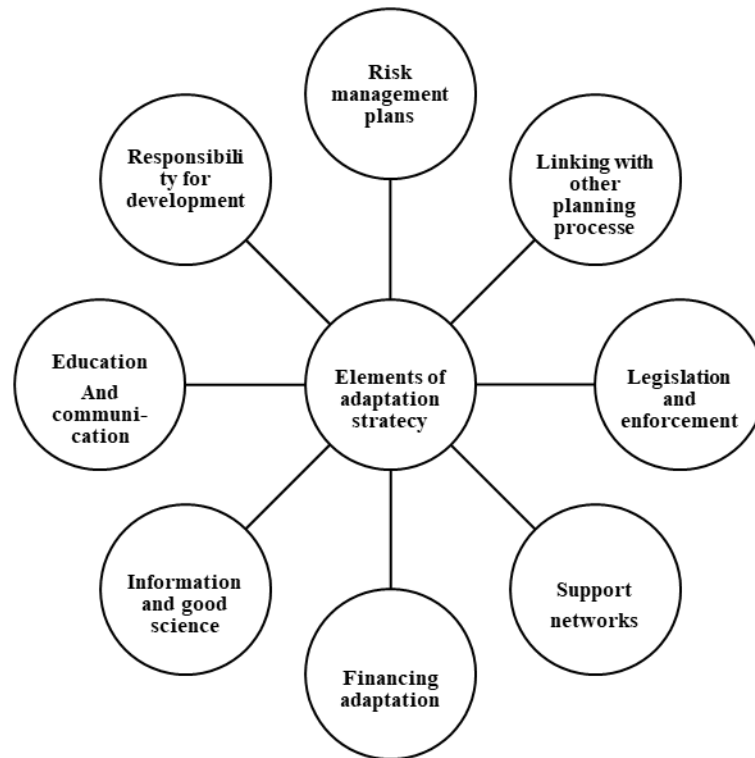


Figure. 2 Essential elements of adaptation strategy
 Source: Tompkins et al. (2005) – Surviving climate change in small islands

A number of studies regarding the impact of climate change on the performance of tourism actors reveal that there is still low awareness of climate change and a lack of long-term strategic planning in the tourism sector in anticipating future climate change (Siddiqui & Imran, 2018). For this reason, mainstreaming adaptation in the tourism industry and government policies still needs attention.

The following are key steps that need to be taken by island countries and developing countries to increase awareness and adaptive action to face the problem of climate change.

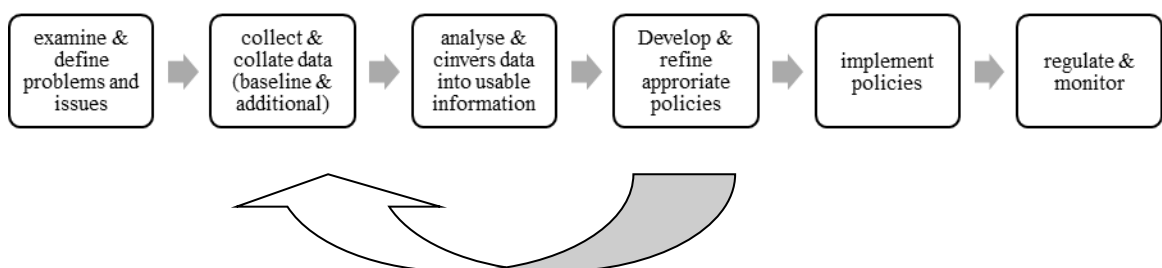


Figure. 3 The climate change and tourist information and implementation (nexux data and policy process requirements for developping countries and small island developping state

Source: Modified, (Simpson et al., 2008, (Farsari, 2023)

Adaptation activities for the marine tourism sector

On the Coremap website, a government collaboration program with the stakeholders, regarding coral reef rehabilitation and management programs, a number of mitigation and adaptation (Suraji et al., 2014) that can be carried out are outlined as follows:

1. Maintain the health of the underwater ecosystem

By maintaining the health of the underwater ecosystem, coral reefs will be healthy again and appear beautiful, as well as populations of beautiful marine fish will grow. These actions are:

- Reduce fishing around coral reef areas which are tourist destinations for diving and snorkeling activities.
- Develop prohibited zones or fishing, diving and snorkeling areas
- Separate diving and snorkeling zones from fishing or fishing zones to reduce conflict.
- Stop fishing practices using methods that damage the underwater environment and reduce fish populations.

2. Involving Tourists in Bleaching Issues.

Many divers and snorkellers want to be involved in coral reef conservation activities and would welcome the opportunity to participate in initiatives related to the restoration of bleached coral reefs. Fish observation plans and amateur coral reef monitoring programs are increasing, for example the organizations REEF (Reef Environmental Education Foundation) and CEDAN (Preservation, education, diving knowledge and marine research/Conservation, Education, Diving, Awareness and Marine-research), both based in America, and other organizations operating on an international scale (such as Coral Cay Conservation, Frontier, Raleigh, Earthwatch, Reef Check). For example, in the Bonaire Marine Park, the Netherland Antilles Islands, which receive annual visits from REEF and CEDAN, these visits form an integral part of the national park's monitoring program. (Biorock image, coral reef mineral accretion, source:

3. Diversify the tourism industry.

In order to monitor changes in tourist visits to coral reefs, regular surveys should be carried out, for example, in airport departure lounges while tourists are waiting for their flights. Several countries have carried out such surveys with the implementers being the departments responsible for tourism. Survey questions can be specific to diving and snorkeling and other activities directly related to coral reefs or even other broader tourism activities. Monitoring changes in the tourism market will indicate whether the marketing of alternative tourism activities is necessary to sustain the industry. Regional tourism activities, for example, could be the focus while damaged coral reefs are given the opportunity to recover; However, care must be taken to ensure that coastal development activities themselves do not increase damage to coral reefs. Greater attention should be paid to the spatial value of an area, clean beaches, clear water for water sports, etc. Searching for new sites or alternative dive sites may also be necessary (e.g. with more dramatic underwater views or large fish populations).

4. Reducing the Impact of Tourism Activities in General.

On coral reefs that have been degraded and bleached, management of tourism activities around them is very necessary. The following impacts, among others, must be reduced or eliminated (see also Other threats to reefs, DPL, Integrated Coastal and Fisheries Management):

- Direct contact from diving or snorkeling (from walking or tapping on the reef); providing information to divers and educating them about the potential dangers they can pose may be useful in eliminating such damage. In addition, offering divers free buoyancy balance workshops may also help control their buoyancy balance underwater, prohibiting the use of gloves, and prohibiting intentional touching of coral reef organisms.
- Dive sites or coral reefs are overused; relocating dive sites or limiting the number of divers at popular dive sites can all reduce damage to coral reef areas in the process of recovery.
- Physical damage to anchoring vessels (diving, fishing, yachting, etc.) can be managed by

designating anchoring zones, providing options, such as mooring, and enforcing other regulatory requirements regarding environmentally friendly anchoring.

- Contamination from waste dumping near the coast (e.g. waste from resorts); It might be more appropriate for beach resorts to process wastewater or recycle it for maintaining their gardens so that the waste nutrients can be used by plants.
- Sedimentation and pollution from building construction (e.g. small and large wharves, harbors and marinas); Guidance is available for various construction activities and their implementation, and various methods have been developed to reduce these impacts. This can be improved and implemented by establishing conditions for approving environmental impact evaluation plans through regulatory and licensing systems and also with incentives.

5. Encourage tourists to contribute funds to recovery and management efforts.

Managing coral reefs, both healthy and recovering from damage, requires adequate funding sources which are something the most critically affected countries lack. The tourism industry, which relies on or makes extensive use of coral reefs found in many areas, must contribute to the management of coral reef protection. Individual divers and tourists can help by paying the park entrance fee and by donating.

6. Disseminate Information to the Public Through Education and Other Propaganda.

The tourism industry can play an important role in education and other propaganda activities. The strategy used for this purpose is as follows:

- Brochures on “dos and don'ts” when enjoying coral reefs and on the relationship between climate change and coral bleaching, included in information packages provided by hotels to their guests.
- Using Social Media or Digital Marketing methods to promote the education and attitude towards climate change and coral reefs.
- Informative and colorful posters sold at local tourist shops or park offices.
- Training courses for tourism workers to teach tourists about the biology and threats to coral reefs.
- Free boat tours from DPL and lectures with slides for community members, especially those who work extensively with tourists, so that they have a sense of responsibility for their coral reefs and will help teach the tourists they meet.

Meanwhile, for institutional capacity, adaptations can be made (Hidayat et al., 2017; Suraji et al., 2014; Susanto et al., 2015) as follows:

- 1) Institutional Strengthening: increasing government institutional support for collaborative management of marine protected areas and other protected marine areas with coastal communities.
- 2) Community-Based and Collaborative Management: increasing the income of all coastal communities and their institutions in the program district by sustainably managing coral reefs and their ecosystems together.
- 3) Public Awareness, Education and Extensification: increasing public awareness about the benefits of conservation of coral reef ecosystems and their sustainable use which results in changes to destructive practices.

CONCLUSIONS

To summarise, the study provides an overview of the influence of climate change and the potential impact on coral reef bleaching and its consequences on the tourism sector that may occur in Indonesia. Also explained are the global climate changes that will occur in the future (especially predictions for the year 2100) as well as projections of changes in the Indonesian climate in the annual temperature and rainfall components under any scenarios. Then, in the final section, appropriate countermeasures and adaptation efforts are outlined for the Indonesian tourism sector, so that at least the impact of climate change is expected to be in line with the projected results. (1) Maintain the health of the underwater ecosystem, (2) Involving Tourists in Bleaching Issues, (3) Diversify the tourism industry, (4) Reducing the Impact of Tourism Activities in General, (5)

Encourage tourists to contribute funds to recovery and management efforts, (6) Disseminate Information to the Public Through Education and Other Propaganda. Meanwhile, for institutional capacity, adaptations can be made as follows: (1) Institutional Strengthening, (2) Community-Based and Collaborative Management, (3) Public Awareness, Education and Extensification.

Some of the findings support previous research; however, the findings of this study caution organisational researchers to carry out any related mitigation and adaptation research for tourism sector and industry, including in the domain of sustainable tourism.

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