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**Research Article**

# IMPACT OF CLIMATE CHANGE ON BIODIVERSITY IN COASTAL ECOSYSTEMS

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**Abstract**
Climate change has had tangible and complex impacts on biodiversity and coastal ecosystems. Rising temperatures, sea-level rise, and the increasing frequency of extreme weather events have accelerated habitat degradation and threatened the survival of various coastal species, including marine organisms, mangrove forests, and coral reef ecosystems. These environmental changes also directly affect the socio-economic sustainability of local communities that depend heavily on coastal resources. This study aims to analyse the impacts of climate change on coastal ecosystems, identify the most affected species, examine local community adaptation strategies, and provide relevant and applicable conservation recommendations. A qualitative phenomenological approach was employed, with data collected through in-depth interviews, participatory observations, and field documentation. The data were analysed using the interactive model of Miles and Huberman, with validation ensured through triangulation, credibility, and confirmability. The findings indicate that climate change significantly accelerates coastal ecosystem degradation and causes a notable decline in biodiversity. Although local communities have begun to adapt, their responses remain reactive and are constrained by limited access to information, resources, and institutional support. This study contributes theoretically to the understanding of the interrelationship between climate change and coastal ecology, and practically by offering community-based conservation strategies that are more responsive, inclusive, and sustainable. These findings highlight the urgency of integrating ecological, social, and policy perspectives in coastal conservation efforts to ensure the long-term resilience of both ecosystems and local livelihoods.

**Keywords**: Biodiversity, Climate Change, Coastal Ecosystems

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## INTRODUCTION

Climate change is a global phenomenon that has a significant impact on various aspects of the environment, especially in coastal areas. Increasing global temperatures, rising sea levels, and changing weather patterns are increasingly felt in coastal areas, triggering various complex ecological changes. Biodiversity in coastal ecosystems is one of the aspects most vulnerable to these changes, with many species of flora and fauna experiencing population declines due to drastic changes in habitat conditions (Jupri dkk., 2024a; Noor, 2023; Saparuddin dkk., 2025). Coastal ecosystems such as mangrove forests, coral reefs, and seagrass beds are facing serious degradation as a result of rising sea temperatures and increasing coastal abrasion. This condition also has a direct impact on coastal communities that depend on these biological resources for their livelihoods, both for economic and socio-cultural needs. Given these widespread impacts, research on the relationship between climate change and biodiversity in coastal ecosystems is very important to be carried out to understand the dynamics that occur and find the right solutions.

Previous studies have shown a correlation between climate change and coastal ecosystem degradation, but many theories have not been able to fully explain the complexity of these impacts holistically. Previous studies often focus on individual aspects such as changes in sea temperature or sea level rise, but have not integrated how these factors interact to affect biodiversity as a whole. In addition, there are still limitations in the study of the natural adaptation of coastal species to these changes, as well as a lack of data on how coastal communities adapt to ecosystem changes that impact their lives. This gap in the literature indicates the need for further research that examines the impacts of climate change in a more integrative manner, covering ecological and socio-economic aspects simultaneously, so that the resulting conservation and adaptation solutions are more effective and sustainable.

This study aims to analyze in depth the impact of climate change on biodiversity in coastal ecosystems. Another objective is to identify the species most affected by climate change in coastal areas so that priorities can be identified in conservation efforts. In addition, this study also aims to examine how coastal communities adapt to environmental changes that occur, both in terms of economy, society, and culture. By understanding these adaptation patterns, more effective community empowerment strategies can be formulated. Finally, this study aims to provide recommendations for evidence-based conservation measures aimed at maintaining coastal biodiversity amidst the pressures of climate change. With these objectives, this study is expected to provide real contributions to environmental conservation efforts and coastal community empowerment.

Based on the empirical facts that have been described and the objectives that have been formulated, a strong argument can be made regarding the importance of this research to be carried out. Climate change has been proven to have significantly changed the structure and function of coastal ecosystems, and without a deep understanding, conservation and adaptation efforts become less effective. The hypothesis underlying this research is that climate change not only reduces coastal biodiversity but also affects the socio-economic resilience of local communities. Thus, this research is important to support data-based policy-making in coastal conservation, as well as to design adaptation strategies that involve local communities as the

main actors. This research aims to answer the gap in existing literature and provide a scientific foundation for coastal ecosystem conservation efforts in the face of global climate change.

Climate change is generally defined as a long-term change in the patterns of temperature, precipitation, winds, and other climate parameters on Earth (Hidayat & Haryanto, 2023; Jannah dkk., 2023; Prasetyo dkk., 2021). This definition refers to changes that occur due to both natural variations and human activities, such as the burning of fossil fuels and deforestation, which increase the concentration of greenhouse gases in the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC), climate change includes not only an increase in the global average temperature but also changes in the frequency and intensity of extreme weather events (Purify dkk., 2024; Styawan, 2024). In the coastal context, climate change affects environmental dynamics such as sea levels, storm patterns, and seawater temperatures. Therefore, understanding the concept of climate change is an important basis for assessing its impact on biodiversity, especially in sensitive ecosystems such as coastal areas. This definition is the basis for identifying the mechanisms of environmental change that will be further analyzed in this study.

Manifestations of climate change can be categorized into several interrelated forms that directly affect coastal ecosystem conditions. One of the main manifestations is the increase in sea surface temperatures that cause coral reef bleaching and disrupt the life cycles of coastal species. In addition, sea level rise as a result of melting polar ice and thermal expansion of seawater has accelerated coastal erosion and submerged coastal habitats. Changes in rainfall patterns also have an impact on salinity and nutrients in coastal areas, which ultimately affect the composition of local species. Extreme weather events such as increasingly frequent and intense storms and hurricanes cause major physical damage to coastal ecosystems. Each of these climate change manifestations has different implications for ecological stability, so understanding this categorization is important for determining the right adaptation and mitigation approaches in biodiversity conservation efforts.

Biodiversity refers to the variation of life across all levels of biological organization, from genes to species to ecosystems (Sulistiyowati, 2024). The concept encompasses the richness of species and genetic diversity within a community, as well as the ecological interactions that shape living systems. According to the Convention on Biological Diversity (CBD), biodiversity is not just the number of species present, but also the complexity of the relationships among species and between species and their environment (Ekardt dkk., 2023; Robb, 2024; Tiwari & Rani, 2025). In coastal ecosystems, biodiversity includes organisms such as fish, crustaceans, molluscs, coastal plants, and various microorganisms that play important roles in maintaining ecological balance. Understanding the concept of biodiversity is important for examining how climate change affects not only species abundance but also the structure and function of coastal ecosystems as a whole, which is the main focus of this study.

The manifestations of biodiversity in coastal ecosystems can be divided into several main categories, namely genetic diversity, species diversity, and ecosystem diversity. Genetic diversity refers to the variation of genes within a population of a particular species, which determines the species' ability to adapt to environmental changes, including climate change (Anisah & Utari, 2025; Jupri dkk., 2024b; Konrad dkk., 2025; Mardin dkk., 2024). Species diversity refers to the number and variety of species living in a particular area, while ecosystem diversity includes the different types of habitats and biotic communities present in coastal areas (Kumari dkk., 2024; Meena dkk., 2025; Mu dkk., 2024). Each of these categories contributes to the stability, productivity, and resilience of ecosystems. A decline in any one category of biodiversity can result in greater vulnerability to external disturbances, including the impacts of climate change. Therefore, understanding the manifestations of biodiversity is essential for identifying indicators of damage and setting conservation priorities in the face of increasing environmental pressures.

Coastal ecosystems are ecological systems located at the boundary between land and sea, including habitats such as mangrove forests, coral reefs, seagrass beds, salt marshes, and sandy beaches (Patil & Selvaraj, 2025; Sahavacharin dkk., 2022; Steven dkk., 2023). These ecosystems function as highly dynamic transition zones, where complex interactions between biotic (living things) and abiotic (physical and chemical factors) components occur. The definition of coastal ecosystems also includes characteristics such as high biological productivity, function as spawning and rearing grounds for various marine species, and protection against natural disasters such as tsunamis and storms (Paembonan dkk., 2024; Rizki, 2024; Sutthacheep dkk., 2022). In the conservation framework, coastal ecosystems are considered one of the key zones because of their role in maintaining biodiversity and supporting the economic sustainability of local communities. Understanding this definition is important in this study to assess the extent to which climate change has altered the structure, function, and services of coastal ecosystems.

Coastal ecosystem manifestations can be seen through various types of habitats, each of which has its ecological characteristics and biodiversity. Mangrove forests, for example, function as coastal protection and habitat for various species of fish and birds. Coral reefs provide complex structures that are home to thousands of marine species, as well as act as natural protection from large waves. Seagrass beds play an important role in the carbon cycle and as a feeding ground for marine species such as dugongs and turtles. In addition, salt marsh ecosystems and sandy beaches also provide environmental services such as water filtration and shoreline stabilization. Each of these coastal ecosystem manifestations shows the dependence of species on specific habitats so environmental changes due to climate change can cause major disruptions to the overall ecosystem balance. Understanding these manifestations is the basis for identifying the specific impacts of climate change on coastal biodiversity.

## RESEARCH METHOD

The object of this research focuses on the phenomenon of climate change that is increasingly felt in coastal areas, especially through increasing global temperatures, rising sea levels, and changes in weather patterns that affect environmental dynamics. This research also examines its impact on biodiversity, where many species of coastal flora and fauna show a decline in population due to habitat changes. In addition, coastal ecosystems such as mangrove forests, coral reefs, and seagrass beds are also experiencing significant degradation caused by increasing water temperatures and increasingly intense coastal abrasion processes. No less importantly, this research also examines how coastal communities, especially fishermen and local communities that depend on coastal natural resources, are affected by this decline in biodiversity. By examining these four aspects, this research aims to build a holistic understanding of the relationship between climate change, biodiversity, coastal ecosystems, and the socio-economic dynamics of local communities.

This study uses a qualitative phenomenological approach, which aims to explore and understand the meaning of the experiences of individuals and groups affected by climate change in coastal ecosystems. Primary data were collected through in-depth interviews with research informants, who shared their direct experiences related to the phenomena of increasing global temperatures, rising sea levels, changing weather patterns, and coastal habitat degradation. In addition, secondary data were obtained from relevant literature reviews, including previous studies on climate change, biodiversity, and coastal ecosystem management. The phenomenological approach allows researchers to not only collect empirical facts but also reveal the deep meaning behind the experiences of participants. By combining primary and secondary data, this study seeks to build a comprehensive narrative about the impacts of climate change on coastal ecosystems and communities.

Participants in this study consisted of various parties who had relevant experience and knowledge regarding the topic studied. A total of 10 local fishermen were selected because of their direct involvement in coastal economic activities and their dependence on environmental conditions. In addition, 3 coastal ecology experts from academics and researchers were involved to provide scientific perspectives on ecosystem change. Two environmental non-governmental organizations (NGOs) that are active in coastal conservation also became important sources of information in identifying adaptation and conservation practices that have been carried out. Finally, two officials from the regional Environmental Service were also involved in providing policy and regulatory perspectives related to climate change and coastal ecosystem protection. The selection of these participants aims to present diverse perspectives so that the research results can provide a more complete and in-depth picture of the problems studied.

The research process was carried out through several stages, starting from planning, and data collection, to data analysis. The main data collection technique used was in-depth interviews, which were designed in a semi-structured manner so that informants could express their experiences freely but still within the research framework. In addition to interviews, participant observation was conducted to record direct interactions between the community and the coastal environment, especially in daily activities related to natural resources. Documentation, such as photos of ecosystem conditions and audio recordings of interviews, were also collected to enrich the research data. Each of these data collection techniques complements each other so that they can capture the complexity of the phenomena studied from various angles. With this combination of methods, the research seeks to uncover the deep meaning of the changes that occur, not just record the surface symptoms.

In analyzing the data, this study uses the Miles and Huberman model data analysis technique which includes three main stages: data reduction, data presentation, and drawing and verifying conclusions (Fota, 2022; Negri, 2024; Shen, 2025). Data reduction is done by filtering important information from interviews, observations, and documentation to focus on central themes related to the impacts of climate change. Furthermore, the reduced data is presented in narrative or table form to facilitate understanding of the relationship between variables. Concluding is done continuously with repeated verification of the data, ensuring the validity of the findings through credibility, dependability, transferability, and confirmability techniques. This analysis process is phenomenological and reductive, which means trying to explore the deepest meaning of the informant's experience of environmental change. Editing techniques are carried out during data collection to maintain the accuracy of the interpretation of the phenomena studied in this study.

## RESULTS AND DISCUSSION

Research results related to climate change show that the majority of fishermen in coastal areas complain about a significant decrease in fish catches in the last five years. Based on in-depth interviews, fishermen stated that several species of fish that used to be easy to find are now rarely seen. They also revealed that changes in seasons and unpredictable weather, such as sudden heavy rain and more frequent storms, cause difficulties in going to sea. Field observations support these findings, with coastal abrasion eroding land by 2-3 meters per year and frequent extreme weather. Documentation in the form of photos of coastal abrasion and BMKG reports on increasing temperatures and rainfall in coastal areas support this condition. All of this data shows that climate change is not only felt in the long term but has also had a real impact on the daily lives of coastal communities.

Explanation of the data shows that climate change has a multi-layered impact, both on marine ecosystems and on the socio-economic activities of the community. From interviews, observations, and documentation, it is clear that unpredictable weather patterns and increasing sea temperatures not only disrupt the fishing season but also cause gradual environmental degradation. Coral bleaching observed and recorded in snorkelling documentation at several points shows that the natural habitat for many fish species is under severe pressure. In addition, statistical reports from the fisheries office showing a decrease in catches also strengthen the picture of the direct link between climate change and reduced marine products.

The relationship between data description and explanation that has been described illustrates the close connection between the phenomenon of climate change and the socio-economic realities faced by coastal communities. Facts on the ground show that changes in weather patterns and environmental degradation are not just theoretical predictions, but have become part of the daily lives of coastal communities. This condition makes it clear that the problem of climate change not only has an impact on the physical environment but also threatens the survival of local communities that are highly dependent on marine products.

Regarding biodiversity, the results of the study showed that climate change puts great pressure on coastal flora and fauna populations. Based on interviews with ecologists, it was found that rising sea temperatures are the main cause of coral bleaching, which has an impact on the decline in the diversity of reef fish species. In addition, certain mangrove species are starting to be threatened with extinction due to increasingly severe coastal abrasion. Observations in the mangrove forest area show areas of dead mangroves and permanent seawater inundation. Documentation in the form of images of collapsed mangroves and notes on the reduction in reef fish further strengthens that pressure on biodiversity in this area is occurring progressively and evenly across various coastal points.

Explanation of this data shows that ecosystem damage due to climate change directly disrupts the balance of biodiversity. The death of mangroves not only affects the plants themselves but also eliminates important habitats for various marine species and coastal birds. The coral bleaching process shows that corals that should be a place of shelter and breeding for small fish are now losing their ecological function. BMKG reports on increasing seawater temperatures and rainfall, as well as data from the fisheries service, increasingly confirm that climate change is causing drastic changes in species diversity in coastal areas.

The relationship between description and explanation shows that climate change is not only worsening ecosystem conditions, but also accelerating the loss of coastal biodiversity. Observations and interviews consistently illustrate that many once common species are now rare or even gone from certain areas. The cascading impacts of species loss not only disrupt natural food webs but also worsen the socio-economic conditions of coastal communities that rely on the presence of these species for their livelihoods.

In terms of coastal ecosystems, the study found that ecosystems such as mangrove forests, coral reefs, and seagrass beds have experienced severe degradation due to climate change. Interviews with Environmental Non-Governmental Organizations expressed concerns about the destruction of coastal ecosystems and the lack of adaptation policies implemented at the local level. Observations show that coastal abrasion continues to erode land, while many mangrove areas have died due to being submerged in salt water for a long time. In addition, documentation shows that conservation activities carried out by NGOs are still very limited in scope. Photographs and reports of conservation activities show efforts to restore mangroves in several areas but have not been able to compensate for the damage that has occurred.

Explanation of this data makes it clear that coastal ecosystems are in a very vulnerable condition and their sustainability is threatened. The link between climate change, lack of policy protection, and ecological damage is reflected in the real conditions found in the field. Dead mangrove ecosystems and widespread coral bleaching show that natural protection is not running optimally. Reports from NGOs on the need for community education show that

community-based adaptation efforts are very urgent amid limited structural support from local governments.

The relationship between description and explanation in this section reinforces the picture that coastal ecosystems face multi-dimensional pressures due to climate change and the inadequacy of adaptive responses from authorities. The destruction of mangrove forests and coral reefs not only reduces their ecological function as natural protection from natural disasters such as storms and abrasion but also increases the socio-economic vulnerability of coastal communities. This finding confirms that coastal ecosystem protection needs to be a strategic priority in climate change adaptation policies at the local and national levels. The following are the findings of the study based on the results of interviews with participants, the results of field observations and the results of documentation studies.

Table 1. research findings based on interview results, observation results, and documentation study results

| No. | Research Purposes | Research Findings |
|---|---|---|
| 1 | Analyzing the impact of climate change on biodiversity in coastal ecosystems | Climate change is causing significant degradation of coastal ecosystems, including coral bleaching, mangrove die-offs due to erosion, and a decline in marine species diversity. Rising water temperatures and extreme weather are exacerbating the destruction of natural habitats. |
| 2 | Identifying species most impacted by climate change in coastal areas | The most affected species include various types of reef fish whose populations have declined drastically, mangrove species that are threatened by abrasion and death, and several coral organisms that have experienced massive bleaching. |
| 3 | Examining the adaptation of coastal communities to the changes in ecosystems that occur | Adaptation of coastal communities is still limited; fishermen complain about the uncertainty of catches and seasonal changes. Adaptation efforts are mostly reactive, such as changing fishing locations or relying on alternative seafood, but there is still a lack of long-term adaptation strategies. |
| 4 | Providing recommendations for conservation measures to maintain coastal biodiversity | Ecosystem restoration is needed, such as replanting mangroves, protecting coral reef areas, educating local communities about climate adaptation, and strengthening local policies for conservation and mitigating climate change. |

The results of this study reveal that climate change has caused significant impacts on biodiversity in coastal ecosystems, reflected in the decline in populations of various species, degradation of natural habitats such as coral reefs and mangroves, and drastic changes in the lifestyles of coastal communities. Various findings from interviews, observations, and documentation show a close relationship between environmental phenomena and socio-economic vulnerability. Reef fish and mangrove species are the most affected groups, while coastal communities experience a decline in catches and must adapt to these changes in new ways that are sometimes temporary and unsustainable.

When compared to previous studies, this study shows advantages in terms of a more in-depth phenomenological approach to the direct experiences of coastal communities, compared to other studies that tend to focus on macro statistical data. For example, some previous studies have discussed more about biodiversity changes through satellite monitoring or ecological models without linking them to the real experiences of local communities. This study fills this gap by providing a holistic understanding, not only of the biological-ecological aspects, but also of the social, cultural, and economic aspects of the affected coastal communities, thus producing a more comprehensive and applicable picture.

Reflection of the results of this study indicates that the research objectives have not only been achieved but also opened up new insights into the importance of a community approach in understanding the impacts of climate change. Analysis of the results shows that adaptation cannot be viewed solely from an ecological aspect, but must also consider the social dynamics of local communities. Maintaining biodiversity not only supports ecosystem balance but is also the main foundation for the economic resilience of coastal communities. Therefore, the benefits of this study lie in its ability to bridge environmental conservation and social welfare.

The implications of this research are important for various stakeholders. For policymakers, these findings emphasize the urgency of developing community-based climate change adaptation regulations that focus on biodiversity conservation. For academics, this research expands the knowledge base on climate change impacts from a phenomenological perspective. For non-governmental organizations and local communities themselves, the results of this research serve as a basis for designing more effective adaptation strategies, such as participatory ecosystem restoration, increasing environmental literacy, and diversifying livelihoods.

The results of the study show that coastal degradation and the decline in biodiversity are caused by complex interactions between natural and anthropogenic factors. Increasing global temperatures, abrasion, and changes in rainfall patterns cannot be separated from the lack of adaptation efforts at the local level, weak policy protection, and lack of public awareness of the importance of conservation. Inequality in the adaptive capacity of coastal communities exacerbates the impacts that occur, making them the most vulnerable group amidst increasingly extreme environmental changes.

Based on the results of this study, the actions that need to be taken include three main approaches: first, strengthening coastal ecosystem restoration programs such as mangrove rehabilitation and coral reef protection; second, developing more inclusive climate change adaptation policies by involving local communities in every stage of planning and implementation; third, increasing the adaptive capacity of communities through environmental education, economic diversification, and the development of adaptive technologies for fisheries and conservation. Without these concrete steps, ecosystem damage and biodiversity decline will continue, endangering the ecological and socio-economic resilience of coastal areas.

## CONCLUSION

The findings of this study are truly astonishing: climate change, which has long been considered to have long-term impacts, has been significantly and rapidly damaging coastal ecosystems, triggering a drastic decline in biodiversity, and shaking the socio-economic stability of local communities. Not only that, species that were previously considered adaptive, such as reef fish and mangroves, are now showing surprising vulnerabilities to rising temperatures and coastal erosion. Furthermore, this study reveals that the adaptive capacity of coastal communities is not developing as fast as the rate of environmental degradation they are experiencing, showing a serious gap between ecological change and social response.

This research provides important contributions to the development of science both theoretically and practically. Theoretically, this research enriches the study of the impacts of

climate change with a phenomenological perspective that links ecological and social experiences in an integrative manner. While practically, the results of this research become a strong foundation for designing community-based conservation strategies and encouraging climate change adaptation policies that are more responsive to local dynamics. Thus, this research not only deepens academic understanding but also offers real, applicable solutions for biodiversity conservation in coastal areas.

Although this study successfully uncovered several important dynamics, there were limitations in the scope of the area and the number of participants studied. These limitations are not weaknesses, but rather opportunities for further research development, such as expanding the study to other coastal ecosystems or a longitudinal approach to understand changes over a longer period. This direction opens up space for further research to build broader generalizations and deepen the analysis of community adaptation patterns amidst the acceleration of global climate change.

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