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The Impact of Climate Change on Ecosystems and Human Activities

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ABSTRAK

Perubahan iklim merupakan fenomena global yang ditandai oleh peningkatan suhu rata-rata bumi akibat meningkatnya konsentrasi gas rumah kaca di atmosfer. Fenomena ini tidak hanya menjadi isu lingkungan, tetapi juga berkembang menjadi tantangan multidimensional yang memengaruhi stabilitas ekosistem dan keberlanjutan kehidupan manusia. Penelitian ini bertujuan untuk menganalisis secara komprehensif dampak perubahan iklim terhadap ekosistem dan kehidupan manusia, serta mengidentifikasi berbagai upaya mitigasi dan adaptasi yang dapat dilakukan untuk mengurangi risiko yang ditimbulkan. Metode penelitian yang digunakan adalah studi literatur dengan mengkaji berbagai sumber ilmiah, termasuk jurnal bereputasi, laporan lembaga internasional, dan publikasi resmi yang relevan dengan topik penelitian. Hasil kajian menunjukkan bahwa perubahan iklim berkontribusi signifikan terhadap degradasi ekosistem, yang ditandai dengan meningkatnya frekuensi bencana alam, perubahan pola curah hujan, serta hilangnya keanekaragaman hayati akibat terganggunya habitat alami. Selain itu, dampak perubahan iklim juga dirasakan pada berbagai sektor kehidupan manusia, seperti penurunan produktivitas pertanian, meningkatnya risiko penyakit, kerugian ekonomi, serta munculnya ketimpangan sosial. Kondisi ini menuntut adanya respons yang terintegrasi dan berkelanjutan. langkah strategis yang melibatkan berbagai pemangku kepentingan melalui penerapan kebijakan mitigasi, seperti pengurangan emisi gas rumah kaca, serta strategi adaptasi yang mencakup penguatan ketahanan masyarakat dan ekosistem. Kolaborasi global dan komitmen bersama menjadi kunci utama dalam menghadapi tantangan perubahan iklim secara efektif dan berkelanjutan.

ABSTRACT

Climate change is a global phenomenon characterized by an increase in the Earth's average temperature due to rising concentrations of greenhouse gases in the atmosphere. This phenomenon is not only an environmental issue but has also evolved into a multidimensional challenge that affects ecosystem stability and the sustainability of human life. This study aims to comprehensively analyze the impacts of climate change on ecosystems and human life, as well as to identify various mitigation and adaptation efforts that can be undertaken to reduce the associated risks. The research method employed is a literature review, examining various scientific sources, including reputable journals, reports from international organizations, and relevant official publications related to the research topic. The findings indicate that climate change significantly contributes to ecosystem degradation, characterized by an increase in the frequency of natural disasters, changes in rainfall patterns, and the loss of biodiversity due to the disruption of natural habitats. Additionally, the impacts of climate change are felt across various sectors of human life, such as reduced agricultural productivity, increased disease risks, economic losses, and the emergence of social inequalities. These conditions demand an integrated and sustainable response strategic steps involving various stakeholders through the implementation of mitigation policies, such as reducing greenhouse gas emissions, as well as adaptation strategies that include strengthening the resilience of communities and ecosystems. Global collaboration and shared commitment are key to effectively and sustainably addressing the challenges of climate change

1. INTRODUCTION

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Various studies have examined the impacts of climate change on ecosystems, particularly in coastal and marine areas. Research indicates that rising sea temperatures and sea-level rise are causing damage to coral reefs and a decline in fish populations due to the loss of natural habitats (Hoegh-Guldberg, 2007; Hughes, 2017). Additionally, the increasing intensity of storms is accelerating coastal erosion and damaging the structure of coastal ecosystems (Nicholls & Cazenave, 2010). These impacts are not only ecological but also affect the economic sustainability of coastal communities (Barbier, 2015). Other research also reveals that climate change accelerates environmental degradation through the interaction between natural factors and human activities (Halpern, 2008). This indicates that coastal ecosystems are among the regions most vulnerable to climate change.

Consequently, sustainable mitigation efforts are needed to maintain the stability of these ecosystems. In addition to coastal ecosystems, terrestrial ecosystems such as tropical forests are also experiencing significant impacts from climate change. Rising temperatures and changes in rainfall patterns lead to forest degradation, a decline in biodiversity, and disruption of ecosystem functions (Allen, 2010; Bonan, 2008). These phenomena are exacerbated by human activities such as deforestation and unsustainable infrastructure development (Curtis, 2018). Research indicates that climate change can increase the frequency of forest fires, leading to widespread environmental damage (Flannigan, 2009). Furthermore, changes in environmental conditions also affect the availability of natural resources for local communities (IPCC, 2021). These conditions highlight a close relationship between climate change and pressures on terrestrial ecosystems. Therefore, an integrated approach to natural resource management is required.

The impact of climate change on biodiversity is also a major focus of various studies. Changes in temperature and precipitation cause shifts in species distribution as well as changes in the reproductive patterns and behavior of organisms (Chen, 2011; Parmesan & Yohe, 2003). This has the potential to disrupt interspecies interactions within ecosystems, such as predator-prey relationships (Tylianakis, 2008). In addition, the increasing frequency of extreme events also accelerates the extinction of species that are unable to adapt (Urban, 2015). A review of the literature indicates that climate change is one of the primary causes of the global biodiversity crisis (Ceballos, 2015). These impacts are not limited to specific species but also affect the overall stability of ecosystems (Bellard, 2012). Consequently, the protection of biodiversity has become a top priority in addressing climate change.

On the other hand, climate change also has significant impacts on human activities, particularly in the health and economic sectors. Rising temperatures and environmental changes create conditions that facilitate the spread of infectious diseases, such as vector-borne diseases (Patz, 2005). Furthermore, climate change affects agricultural productivity due to unpredictable growing seasons and an increase in extreme events (Lobell et al., 2011). Research indicates that climate change can reduce global agricultural productivity and increase communities' vulnerability to food crises (Porter, 2014). Economic impacts are also evident in rising losses from natural disasters and decreased labor productivity (Hsiang, 2017). These conditions demonstrate that climate change has far-reaching implications for human well-being.

Other studies also highlight that the impacts of climate change are multidimensional and that environmental and social aspects are interrelated (Adger, 2006). Changes in ecosystem conditions can trigger resource conflicts, population migration, and shifts in social structures (Ummah, 2019). Furthermore, the interaction between climate change and human activities can exacerbate environmental conditions through the overexploitation of natural resources (Steffen, 2011). Research indicates that the impacts of climate change cannot be separated from anthropogenic factors that accelerate environmental degradation (Crutzen, 2002). Therefore, an integrated approach combining ecological and social aspects is necessary to understand the

impacts of climate change. This serves as a crucial foundation for formulating effective adaptation and mitigation policies.

Based on these various research findings, it can be concluded that climate change has complex impacts on ecosystems and human activities, both directly and indirectly. However, most studies still focus on specific aspects, such as coastal ecosystems or biodiversity, without comprehensively integrating their impacts on human activities. Furthermore, studies that simultaneously combine ecological and social approaches remain relatively limited. Therefore, this study offers novelty by comprehensively examining the relationship between climate change, ecosystems, and human activities within a single integrated analytical framework. This study is expected to provide a scientific contribution to enriching multidisciplinary research on climate change and to serve as a foundation for formulating more adaptive and sustainable policies.

2. METHOD

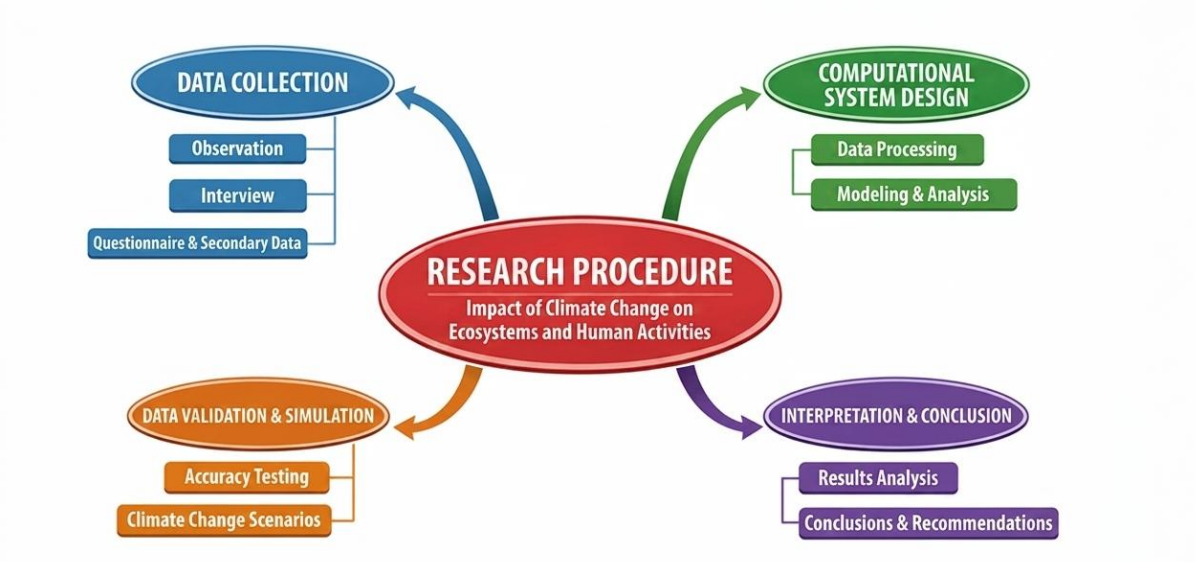
This study employs a qualitative method using a literature review approach, which involves collecting and analyzing data from:

- Scientific journals
- Academic books
- Reports from international organizations
- Government publications

The data were analyzed descriptively to understand the relationship between climate change, ecosystems, and human activities. This study employs a qualitative method using a literature review approach (library research). This approach was chosen because the study aims to deeply understand concepts, theories, and scientific findings regarding the impacts of climate change on ecosystems and human activities based on published sources (Creswell & Poth, 2018). Qualitative methods allow researchers to analyze phenomena comprehensively and contextually (Denzin, 2012).

The data sources for this study consist of secondary data obtained from various reliable references. These data include national and international scientific journals, relevant academic books, official reports from international organizations, and government publications. These sources were selected because they possess high credibility and have undergone a rigorous scientific review process. Data collection was conducted through a systematic literature review. The researcher accessed various scientific databases such as Google Scholar, ScienceDirect, and national journal portals to obtain relevant articles. Additionally, reports from international institutions and government policy documents were reviewed to strengthen the analysis. Literature selection was based on topic relevance, year of publication, and relevance to the research focus (Snow, 2002).

Inclusion criteria for this study encompass sources discussing climate change, its impacts on ecosystems, and its effects on human activities. Meanwhile, exclusion criteria include sources lacking clear references, irrelevant to the topic, or consisting of opinions without a strong scientific basis. Thus, the data used is expected to be valid and reliable. Data analysis was conducted using a qualitative descriptive approach. The collected data was then classified by theme, such as impacts on ecosystems and impacts on human activities. Subsequently, the data was analyzed by comparing various findings from different sources to identify patterns, relationships, and comprehensive conclusions (Miles et al., 2014).



3. RESULT AND DISCUSSION

Result

The impacts of climate change are also reflected in the global decline in biodiversity. According to research findings, many species are experiencing population declines due to the loss of natural habitats and the increasing frequency of extreme weather events. Natural disasters such as floods, storms, and droughts are occurring more frequently and placing additional pressure on the survival of organisms. Endemic species are the most vulnerable group because they have limited capacity to adapt to environmental changes. This decline in biodiversity disrupts ecosystem functions, such as pollination, nutrient cycles, and natural pest control. Furthermore, the loss of certain species can trigger a domino effect within the food chain. Therefore, biodiversity conservation has become an increasingly urgent issue in addressing climate change.

On the other hand, human activities are also significantly impacted by climate change, particularly in the agricultural sector. Changes in temperature and rainfall patterns lead to unpredictable planting seasons, affecting agricultural productivity. Farmers face various challenges, such as increased pest and plant disease outbreaks triggered by shifting climatic conditions. Additionally, droughts and floods can directly damage agricultural land. These conditions have the potential to reduce food security, particularly in developing countries that rely on the agricultural sector. The economic impact of reduced crop yields is also felt by the broader public. Therefore, adaptation strategies in the agricultural sector are needed to address the dynamics of climate change.

In addition to the agricultural sector, climate change also impacts public health and the economy. Rising global temperatures create conditions that favor the spread of infectious diseases, particularly those transmitted by vectors such as mosquitoes. Diseases like dengue fever and malaria are likely to increase in areas that were previously unaffected. Furthermore, declining air quality due to climate change can trigger respiratory problems. From an economic perspective, the increasing frequency of natural disasters causes significant damage to infrastructure and production activities. The costs of rehabilitation and reconstruction place an additional burden on governments and communities. This demonstrates that the impacts of climate change are multidimensional and interconnected across sectors.

Overall, the study's findings indicate that climate change has far-reaching and complex impacts on ecosystems and human activities. The interaction between environmental and social factors creates challenges that require a multidisciplinary approach to address. Mitigation and

adaptation efforts are key to reducing the negative impacts caused. Science-based policies and active community participation are essential for maintaining environmental sustainability. Additionally, the development of environmentally friendly technologies can serve as a solution to address climate change. Thus, synergy among the government, academia, and the community is a critical factor in building resilience to climate change. Integrated strategic measures are expected to sustainably maintain ecosystem balance and human well-being.

Discussion

Climate change is a global phenomenon characterized by an increase in the Earth's average temperature due to the accumulation of greenhouse gases in the atmosphere, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (IPCC, 2021). This phenomenon is largely driven by human activities, including the burning of fossil fuels, deforestation, and industrialization (Purnomo et al., 2023). The impacts of climate change on ecosystems are vast and complex, affecting various biotic and abiotic components as well as the interactions between them (Walther & al., 2002). One of the primary impacts of climate change is the rise in global temperatures, which leads to shifts in species distribution. Many organisms, both animals and plants, are forced to migrate to cooler regions or higher elevations to maintain environmental conditions suitable for their survival (Chen & al., 2011; Parmesan & Yohe, 2003). However, not all species are able to adapt or migrate quickly, thereby increasing the risk of extinction, especially for endemic species and those with limited habitats (Urban, 2015).

In addition, climate change also affects the hydrological cycle, which impacts water availability in various ecosystems (IPCC, 2021). Changes in rainfall patterns can lead to droughts in some regions and floods in others. Ecosystems such as tropical rainforests and wetlands are highly vulnerable to these changes, as water balance is crucial for the survival of the flora and fauna living within them. Prolonged droughts can lead to a decline in primary productivity, while floods can damage soil structure and disrupt the lives of organisms (Allen & al., 2010). Marine ecosystems are also significantly impacted by climate change. Rising sea surface temperatures cause coral bleaching, which occurs when corals lose their symbiotic algae due to temperature stress (Hoegh-Guldberg & al., 2007).

This results in a decline in marine biodiversity, as coral reefs serve as critical habitats for various fish species and other marine organisms. Additionally, rising CO_2 concentrations in the atmosphere cause ocean acidification, which disrupts the ability of marine organisms such as mollusks and crustaceans to form calcium carbonate shells (Doney & al., 2009). Climate change also affects interspecies interactions, such as predator-prey relationships and pollinator-plant relationships (Tylianakis, 2008). Changes in seasonal timing (phenology), such as flowering or migration periods, can cause desynchronization among interdependent species (Thackeray & al., 2016). For example, if plants flower earlier due to warmer temperatures but pollinating insects are not yet active, the pollination process may be disrupted, ultimately affecting plant reproduction and food availability for other organisms.

Climate change has a significant impact on various human activities, particularly in the agricultural sector. Changes in rainfall patterns, rising temperatures, and the increased frequency of extreme weather events such as droughts and floods create uncertainty regarding planting and harvesting seasons (Lobell et al., 2011). Farmers often experience crop failures due to unpredictable weather conditions, which directly impacts food production and food security in a region. Additionally, rising temperatures can accelerate water evaporation from the soil, making the land drier and less fertile for cultivation. In the health sector, climate change also affects human activities through increased disease risks.

Warmer temperatures and changes in rainfall patterns create ideal conditions for the spread of infectious diseases such as malaria, dengue fever, and other waterborne diseases

(Patz, 2005). In addition, increasingly frequent heat waves can cause heat stress and dehydration, leading to higher mortality rates, particularly among vulnerable groups such as the elderly and children (IPCC, 2021). These conditions disrupt people's daily activities, particularly for those working outdoors. Climate change also impacts the economy and infrastructure. Natural disasters such as floods, storms, and rising sea levels can damage public facilities, homes, roads, and transportation networks (Hallegatte & al., 2013). This hinders human mobility and the distribution of goods and services. Additionally, coastal communities face direct threats from coastal erosion and rising sea levels, which may force them to relocate (Nicholls & Cazenave, 2010). These impacts not only result in significant economic losses but also affect social stability and the overall well-being of communities.

The impacts of climate change on human activities include the following:

1. The Wet Dry Season Phenomenon of 2025

   The wet dry season phenomenon in 2025 is characterized by a delayed onset of the dry season and a shorter duration. Although it is the dry season, rainfall remains above normal in many regions of Indonesia (IPCC, 2021). These conditions contrast with the historical climate patterns that have long served as a reference. High rainfall during the dry season disrupts the agricultural sector and water resource management. Farmers face difficulties in determining the appropriate planting patterns. Additionally, the risk of local flooding increases even though, according to the calendar, it is the dry season (Aldrian & Susanto, 2003). This phenomenon is closely related to the interaction between a weak La Niña and global warming . This combination creates atmospheric instability that is difficult to predict. Its impacts demand more flexible and responsive climate policy adaptations.

2. Surge in Hydrometeorological Disasters

   Weather uncertainty in 2025 contributes to a surge in hydrometeorological disasters in Indonesia. Urban flooding, landslides, and strong winds occur with greater frequency (IPCC, 2021; waskitho Try, 2024). Changes in rainfall intensity are a major factor in this increased risk. Areas with high levels of urbanization are the most affected (Guneralp & al., 2017). Drainage systems that are not adapted to extreme rainfall exacerbate flooding conditions (Ashley & al., 2005). Economic losses resulting from disruptions to community activities continue to rise each year (Hallegatte & al., 2013). The BMKG notes that tropical storms in the waters around Indonesia are also becoming more intense. This is linked to rising sea surface temperatures (Knutson & al., 2020). These conditions heighten safety risks for coastal areas and shipping.

   Areas with high levels of urbanization are the most affected by the surge in hydrometeorological disasters. Rapid urban growth is often not matched by adequate spatial planning and infrastructure, particularly drainage systems capable of handling extreme rainfall volumes. As a result, standing water quickly turns into widespread flooding that submerges residential areas, business centers, and public facilities. Additionally, the reduction of green open spaces further diminishes the soil's ability to absorb water, thereby increasing surface runoff (Foley & al., 2005). The resulting impacts are not limited to physical damage but also include economic losses due to the suspension of community activities, disrupted transportation, and rising post-disaster recovery costs year after year.

   On the other hand, the increased intensity of tropical storms around Indonesian waters is also a clear indicator of increasingly extreme climate change. Rising sea surface temperatures play a significant role in intensifying storm energy, resulting in stronger winds and higher waves. These conditions heighten risks for coastal areas, including the

potential for coastal erosion, storm surges, and damage to coastal infrastructure. Additionally, the shipping and fishing sectors face serious threats due to increasingly hostile sea conditions, which can endanger the safety of fishermen and disrupt inter-regional logistics distribution. Overall, this surge in hydrometeorological disasters underscores the urgency of enhancing preparedness, adaptation planning, and strengthening disaster mitigation systems in Indonesia.

3. The Threat of Coastal Erosion in Island Regions

Rising sea levels pose a serious threat to Indonesia's archipelagic regions. Small islands in Maluku and Nusa Tenggara are beginning to experience significant coastal erosion. The shoreline continues to recede due to a combination of high waves and extreme tides. Erosion not only erodes land but also damages coastal ecosystems such as mangroves and coral reefs (Allen, 2010; Bonan, 2008). The loss of these ecosystems accelerates the region's vulnerability to marine disasters. Coastal communities face the risk of losing their homes and livelihoods. This phenomenon is exacerbated by global ice melt, which increases the volume of seawater. Without serious adaptation measures, small islands risk gradually sinking. The social and geopolitical impacts are a long-term concern.

4. The Effects of Climate Change on Ecosystem Degradation and Threats to Biodiversity

Extreme temperature fluctuations are accelerating ecosystem degradation across the globe. Natural habitats are under severe pressure due to rising temperatures and shifting rainfall patterns. Biodiversity is at high risk of losing its ecological balance. Plant and animal species are struggling to adapt to environmental changes that are occurring too rapidly (Hallegatte & al., 2013). Many ecosystems do not have sufficient time to recover. These conditions are accelerating the rate of species extinction worldwide.

5. Forest Fire Risks and the Impact of El Niño

The year 2025 is predicted to carry a high risk of forest fires, particularly in Kalimantan. Rising global temperatures and local droughts increase the potential for wildfires. The El Niño effect exacerbates conditions by prolonging dry periods. Forest fires cause widespread ecological damage and additional carbon emissions. Fire smoke also has a direct impact on air quality and public health (Nicholls & Cazenave, 2010). Economic activities and transportation are often disrupted due to reduced visibility. In addition to environmental damage, forest fires trigger social conflicts over land. Prevention efforts require consistent cross-sectoral coordination. Without effective control, the cycle of fires will continue to repeat.

6. Cryosphere Shrinkage and Arctic Ice Melt

The global cryosphere, including Arctic ice, continues to shrink significantly. Ice melt is occurring faster than previously projected due to extreme temperatures. This phenomenon directly contributes to global sea-level rise. The loss of sea ice also disrupts the Earth's climate system (Guneralp & al., 2017). The reduced reflectivity of ice surfaces accelerates global warming. The impacts are felt as far as the tropics through changes in atmospheric circulation. These conditions serve as an indicator that climate change has reached a planetary scale. Without drastic emission reductions, the shrinkage of the cryosphere will become increasingly uncontrollable (Foley & al., 2005). The long-term threat to coastal regions is becoming increasingly evident as suitable environments for their survival diminish. However, not all species are able to adapt or migrate quickly, thereby

increasing the risk of extinction, particularly for endemic species and those with limited habitats.

Additionally, climate change affects the hydrological cycle, impacting water availability across various ecosystems. Changes in rainfall patterns can lead to droughts in some regions and floods in others. Ecosystems such as tropical rainforests and wetlands are highly vulnerable to these changes, as water balance is crucial for the survival of the flora and fauna within them. Prolonged droughts can lead to a decline in primary productivity, while floods can damage soil structure and disrupt the lives of organisms (Knutson & al., 2020). Marine ecosystems are also significantly impacted by climate change. Rising sea temperatures cause coral bleaching, which occurs when corals lose their symbiotic algae due to temperature stress.

This has led to a decline in marine biodiversity, as coral reefs serve as a vital habitat for various species of fish and other marine organisms. Additionally, rising CO_2 concentrations in the atmosphere cause ocean acidification, which disrupts the ability of marine organisms such as mollusks and crustaceans to form calcium carbonate shells. Climate change also impacts interspecies interactions, such as predator-prey relationships and pollinator-plant relationships. Changes in seasonal timing (phenology), such as flowering or migration times, can cause desynchronization among interdependent species. For example, if plants flower earlier due to warmer temperatures, but pollinating insects are not yet active, the pollination process can be disrupted, ultimately affecting plant reproduction and food availability for other organisms.

4. CONCLUSION

Based on the results of the literature review conducted, it can be concluded that climate change is a global phenomenon that has significant and multidimensional impacts on ecosystems and human activities. The impacts on ecosystems are evident in the increasing frequency of natural disasters, changes in rainfall patterns, habitat degradation, and a decline in biodiversity, all of which have the potential to disrupt the stability and overall functioning of ecosystems. Coastal, marine, and terrestrial ecosystems are the most vulnerable regions due to the simultaneous pressures of climate change and anthropogenic activities.

On the other hand, climate change also directly impacts various aspects of human life, particularly in the agricultural, health, and economic sectors. Climate uncertainty leads to reduced agricultural productivity, increased disease risks, and economic losses due to the rising intensity of disasters. Extreme climate phenomena such as wet droughts, surges in hydrometeorological disasters, and rising sea levels further intensify the complexity of the challenges faced, especially in developing regions like Indonesia. The findings of this study confirm that the relationship between climate change, ecosystems, and human activities is interrelated and inseparable, thus requiring an integrated and multidisciplinary approach. Therefore, mitigation and adaptation efforts must be carried out comprehensively through the reduction of greenhouse gas emissions, the strengthening of ecosystem resilience, and the enhancement of community adaptive capacity.

Furthermore, strong collaboration between the government, academia, and the public is essential in formulating sustainable, science-based policies. The development of environmentally friendly technologies, increased public awareness, and the strengthening of disaster mitigation systems are strategic steps in addressing climate change. Thus, cross-sectoral synergy is expected to create a balance between environmental sustainability and human well-being in the future.

5. SUGGESTIONS

Based on the research findings, it is recommended that efforts to address climate change be carried out in an integrated and sustainable manner, involving various stakeholders. The government needs to strengthen mitigation policies through the reduction of greenhouse gas emissions, enforcement of environmental regulations, and the development of environmentally friendly renewable energy. Additionally, adaptive spatial planning to address climate risks, particularly in coastal and urban areas, needs to be enhanced to minimize the impacts of hydrometeorological disasters.

The public is encouraged to increase awareness and actively participate in environmental conservation through the adoption of eco-friendly behaviors, such as the wise management of natural resources and the reduction of activities contributing to climate change. In the agricultural sector, the implementation of adaptation strategies is necessary, such as the use of climate-resilient crop varieties, adjustments to cropping patterns, and efficient water management to ensure food security.

For the academic community, further research is recommended to examine the impacts of climate change in a more specific and region-based manner, as well as to integrate ecological and social approaches both quantitatively and qualitatively. The development of climate prediction models and early warning systems is also a priority to enhance disaster preparedness.

Furthermore, cross-sectoral collaboration among the government, academia, the private sector, and the public must be strengthened in formulating evidence-based policies. A multidisciplinary approach and technological innovation are key to enhancing the effectiveness of climate change mitigation and adaptation strategies. Consequently, it is hoped that long-term ecosystem resilience and the sustainability of human life will be achieved.

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