

Ecology as the Foundation of Conservation Transformation: A Review From Knowledge to Policy and Action

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ABSTRACT

This article comprehensively discusses the role of ecology in environmental conservation in the modern era, highlighting the relationship between understanding ecology and the effectiveness of conservation policies and practices. Ecology is explained as the science of interactions between organisms and their environment, from the individual level to the biosphere, which forms the basis for sustainable natural resource management and preservation. Through a qualitative literature review, this article analyzes various contemporary challenges such as climate change, habitat fragmentation, invasive species, pollution, and conflicts between economic interests and conservation. The development of modern technologies such as remote sensing, ecosystem modeling, and big data is also discussed as new opportunities in conservation monitoring and decision-making. This article also emphasizes the importance of a holistic approach and the integration of traditional knowledge, community participation, as well as environmental education from an early age to strengthen conservation efforts. It is concluded that the synergy between ecological science, technological innovation, and the involvement of all stakeholders is crucial for building ecosystem resilience in the face of global pressures. Recommendations include the need for collaborative research based on spatial data, evaluation of conservation policy implementation, and the development of community-based environmental education programs for future sustainability

INTRODUCTION

Background

Krisis ekologi global yang terjadi saat ini telah mencapai tingkat yang belum pernah terjadi dalam human history. Recent data show that wildlife populations have experienced a drastic decline of 73% over the past 50 years (1970-2020), with the sharpest decreases occurring in Latin America and the Caribbean (95%), Africa (76%), and Asia-Pacific (60%). More than 75% of the land surface has undergone significant changes due to human activities, while 85% of wetlands have been lost since 1970. This ecosystem degradation not only threatens biodiversity but also directly impacts human well-being through the loss of ecosystem services, estimated to be worth US\$7 trillion per year, or equivalent to 7% of global GDP (Supriatna, 2024).

The Anthropocene era, characterized by the dominance of human activities over Earth's systems, has fundamentally altered the structure and function of ecosystems. Land-use changes, overexploitation of natural resources, pollution, invasive species, and climate change have become the main drivers of biodiversity loss. The impacts of this ecosystem degradation create a chain effect that threatens food security, water security, public health, and economic stability. Land-use changes driven by increased agri-food exports have caused nearly 80% of the global impact on biodiversity, with extinction rates exceeding planetary boundaries by up to fifty times (Ceglar et al., 2024).

Environmental degradation also has serious impacts on the economic and social well-being of communities. The loss of ecosystem services such as pollination, climate regulation, and the provision of clean water has caused significant economic losses. The decline in pollinator populations has resulted in a 3-5% loss in the production of fruits, vegetables, and legumes globally, affecting the deaths of approximately 427,000 people per year due to reduced consumption of healthy foods. In countries such as Honduras, Nepal, and Nigeria, the economic value of crop production is estimated to be 12-31% lower than the optimal potential due to reduced availability of pollinators (Agustina et al., 2025).

Urgency of the Issue

Facing an increasingly threatening ecological crisis, environmental education has become a crucial strategic instrument to promote transformative behaviors and sustainable policies. UNESCO has called for Education for Sustainable Development (ESD) to become a core component of all education systems at all levels by 2025. An analysis of education plans and curriculum frameworks in nearly 50 countries shows that more than half of them do not mention climate change, while only 19% address biodiversity (Andayani & Suprayitno, 2022).

This crisis is becoming increasingly urgent considering that the global targets set in the Global Biodiversity Framework, the Paris Agreement, and the UN Sustainable Development Goals will not be achieved without more massive action. National commitments and field actions are still far from what is required to achieve these goals and avoid dangerous tipping points. In this context, environmental education not only serves as a transfer of knowledge but also as a catalyst for raising awareness, changing attitudes, and promoting collective action in addressing environmental challenges (Mngomezulu & Ramaila, 2025).

In Indonesia, as a mega-biodiversity country, this challenge becomes increasingly complex considering the economic dependence on the extractive sector and the rapid population growth. Sustainable education programs initiated by the Indonesian government within the framework of the SDGs demonstrate a strong commitment; however, their implementation still faces various obstacles, including a lack of curriculum integration, resource limitations, and resistance to change (Agustin & Nugraheni, 2024; Fajri et al., 2025).

Purpose of Writing

This research aims to: (1) analyze the strategic role of ecology in understanding the complex interactions between biotic and abiotic components within ecosystems; (2) evaluate the effectiveness of conservation education in enhancing biodiversity literacy and promoting pro-environmental behavior; (3) identify challenges and opportunities in the implementation of environmental education in the modern era; (4) formulate a conceptual framework that integrates ecological principles with conservation education strategies to support ecosystem restoration and conservation; and (5) provide policy recommendations and practical strategies to strengthen environmental education as an instrument of social transformation toward sustainable development.

Novelty and Contribution

The novelty of this research lies in an integrative approach that connects theoretical ecological dimensions with practical applications of conservation education in the context of the global biodiversity crisis. Unlike previous studies that tend to separate ecological and educational aspects, this research develops a holistic framework that combines ecosystem understanding with innovative learning strategies. The main contributions of this research include: (1) a comprehensive synthesis of ecological theory and conservation education practices supported by the latest empirical evidence; (2) identification of challenge-based learning models and digital technology as effective approaches for sustainable education; (3) an in-depth analysis of the role of local communities and traditional knowledge in conservation programs; (4) the development of an evaluation framework to measure the effectiveness of conservation education in enhancing biodiversity literacy; and (5) Policy recommendations for strengthening the integration of environmental education into the national education system. This research also provides a methodological contribution through a systematic review approach that integrates literature from various disciplines, as well as a practical contribution through the identification of best practices and innovative strategies that can be adapted in various geographical and socio-economic contexts. Thus, this research is expected to serve as an important reference for academics, education practitioners, policymakers, and environmental activists in the collective effort to build a sustainable future.

LITERATURE REVIEW

1. Concepts and Scope of Ecology

Ecology is a branch of biological science that studies the interactions between living organisms and their environment, both physical and biological. Etymologically, the word ecology originates from the Greek language, namely 'oikos,' which means 'house' or 'dwelling,' and 'logos,' which means 'science' or 'study.' Ecology can be interpreted as the science of the 'house' of life, which studies how organisms adapt, utilize resources, and maintain their existence within a particular natural system. In the modern understanding, ecology, in addition to biological studies, also includes dimensions of social environment, economy, and culture that influence life systems (Wijayanti et al., 2021). Along with the development of scientific knowledge, ecology has evolved into a multidisciplinary discipline. Approaches in ecology now involve integration with geography, environmental chemistry, soil science, and even sociology and anthropology. This is due to the awareness that the interaction of living beings with their environment cannot be understood solely from a biological perspective. Global climate change, besides being related to biological processes, is also closely linked to human socio-economic activities, environmental policies, and the technologies used (Sari & Darmawan, 2022).

The levels of life organization targeted in ecological studies start from the individual, which is the smallest unit of life that has full biological functions. A population is a group of individuals of the same species living in a specific area and capable of reproducing. Above the population is the community, which includes various populations of different species coexisting in a particular area. The next level is the ecosystem, which is an ecological unit consisting of living communities along with their interacting abiotic components. The largest scale is the biosphere, encompassing all ecosystems on Earth as an interconnected whole. (Hakim et al., 2020).

The scope of ecological studies is very broad and can be divided into several branches, such as population ecology, which studies population dynamics and the factors that influence them; community ecology, which focuses on the interactions between species; ecosystem ecology, which emphasizes energy flow and material cycles; and landscape ecology, which examines the spatial relationships between ecosystems. Modern ecology also includes fields such as human ecology, urban ecology, and political ecology, which discuss the impact of social activities and policies on the environment (Handayani et al., 2021).

The role of ecology in understanding the balance of nature becomes very important, especially in an era when environmental degradation and climate change pose global threats. Understanding ecology helps explain how each organism has a role and function in maintaining ecosystem stability. The role of predators in controlling herbivore populations, or the role of plants in the carbon cycle and oxygen production. Without this balance, natural systems would be disrupted and could potentially lead to ecological crises with wide-ranging impacts on human life (Putri & Santosa, 2023).

Ecology is also closely related to environmental conservation efforts. Through understanding biotic and abiotic interactions, humans can design sustainable natural resource management strategies. Ecology-based forest management considers biodiversity, the hydrological cycle, and the balance between timber use and habitat conservation. This approach allows resource utilization without sacrificing long-term ecological functions (Rahman et al., 2020).

Ecological studies cannot be separated from the influence of environmental factors, whether natural or resulting from human activities. Natural aspects such as climate, rainfall, and soil types shape the characteristics of certain ecosystems, whereas human activities such as urbanization, industrialization, and intensive agriculture can alter the structure and function of ecosystems. In some cases, changes caused by humans are irreversible and threaten the preservation of biodiversity. Ecology serves as a scientific foundation for evaluating the environmental impacts of an activity and determining appropriate mitigation measures (Fadilah et al., 2021).

In addition to providing theoretical understanding, ecology also serves as a foundation for environmental policy-making. Ecological data and analysis are used to develop spatial planning, manage conservation areas, and restore degraded ecosystems. Mapping the habitats of rare animals using a spatial ecology approach helps the government determine protection zones and regulate human activities around them. Ecological studies are important not only for researchers but also for policymakers, resource managers, and the broader community (Hidayat & Prasetyo, 2024).

Technological advancements also contribute significantly to ecological studies. The use of remote sensing technology, environmental sensors, and spatial data analysis allows for faster, more accurate, and broader ecosystem observations. This technology helps scientists monitor changes in land cover, measure water quality, or model the impact of climate change on species distribution. The integration of technology and ecology creates new opportunities in predicting and managing environmental dynamics more effectively (Susanto et al., 2023).

Modern ecology also emphasizes a holistic approach, which considers the complex relationships among environmental components and takes into account socio-cultural aspects. Forest management, in addition to paying attention to ecological sustainability, also considers the economic needs of local communities, cultural values, and traditional knowledge that has been passed down through generations. This approach has proven to be more effective because it involves all stakeholders in preserving environmental sustainability (Mulyani & Nugroho, 2022).

With a broad scope of study and high relevance to global environmental challenges, ecology becomes an important pillar in efforts to achieve sustainable development. A deep understanding of ecological concepts and scope not only enhances scientific knowledge but also promotes collective awareness of the importance of maintaining nature's balance. This aligns with the vision of sustainable development, which places environmental conservation as a

foundation for the well-being of present and future generations (Yuliani & Andriani, 2025).

2. Basic Principles of Ecosystems and Interactions Among Components

An ecosystem is a functional unit in ecology composed of biotic and abiotic elements that interact to form a dynamic system. This concept was initially proposed by Tansley in 1935, but it has undergone increasingly comprehensive development over time alongside advancements in scientific knowledge. In an ecosystem, living organisms play a role as part of a complex network that influences each other, while abiotic factors such as climate, soil, water, and sunlight serve as resources and regulators of life processes. The interaction between these two components is key to maintaining the balance and sustainability of the ecological system (Rohman & Dewantara, 2021).

The structure of an ecosystem is formed by two main elements, namely biotic and abiotic elements. Biotic elements include all living organisms, such as producers, consumers, and decomposers, each of which plays a role in maintaining the continuity of energy flow and matter cycles. Producers, such as green plants, convert solar energy into chemical energy through photosynthesis. Consumers, including herbivores, carnivores, and omnivores, utilize that energy in a hierarchical manner. Decomposers, such as bacteria and fungi, break down dead organic matter into simpler compounds that can be reused by producers. Abiotic components such as water, air, minerals, and sunlight provide the physical and chemical conditions that enable life to exist (Azzahra et al., 2022).

Ecosystem functions cannot be separated from the process of energy flow that connects all organisms within a food chain. Energy flows from producers to consumers through the process of eating and being eaten, and then most of it is released back into the environment in the form of heat according to the second law of thermodynamics. This process illustrates that energy cannot be completely recycled, so ecosystems depend on a new supply of energy from the sun. By understanding the principles of this energy flow, humans can assess the efficiency of an ecosystem and identify potential disturbances that may hinder ecological functions (Gunawan et al., 2023). In addition to energy flow, material cycles are also vital elements in ecosystems. These cycles encompass the circulation of essential elements such as carbon, nitrogen, phosphorus, and water as they move through biotic and abiotic components. The carbon cycle regulates the balance of carbon dioxide in the atmosphere through processes of photosynthesis, respiration, and decomposition. Disruptions in this cycle, such as those caused by excessive carbon emissions, can drive climate change that impacts the stability of global ecosystems. Understanding the material cycle helps guide ecosystem conservation and restoration efforts scientifically (Pratiwi & Setyawan, 2020).

In the structure of ecosystems, food chains and food webs represent species interactions. Food chains illustrate the linear flow of energy, while food webs show more complex relationships because most organisms eat and are eaten by more than one species. Food webs create stability in ecosystems by providing alternative pathways for energy flow if one population declines. Disruption of a key species can cause a ripple effect that drastically alters the structure and function of ecosystems (Sutanto et al., 2024).

The principles of interaction among components in an ecosystem not only include trophic relationships but also non-trophic interactions such as competition, predation, mutualism, commensalism, and parasitism. Competition occurs when two or more species utilize the same limited resources, which can influence the distribution and abundance of populations. Predation plays a role in controlling prey populations, whereas mutualism benefits both parties involved. Such interactions drive evolutionary adaptations that affect species survival (Fauziah & Ramadhan, 2021).

Population dynamics in ecosystems are influenced by interactions among organisms and environmental factors. Population growth depends on the availability of resources, reproduction rates, and environmental pressures such as disease or natural disasters. In natural ecosystems, population balance is often achieved through natural regulatory mechanisms such as predation, competition, and disease. Human interventions, such as overhunting or the introduction of invasive species, can disrupt this balance, leading to a decline in biodiversity and increased vulnerability of ecosystems to disturbances (Santoso et al., 2022).

The basic principles of an ecosystem also include the concept of succession, which is the change in species composition and community structure over time. Succession can be primary, occurring in areas that previously had no life, or secondary, occurring after a disruption alters an existing ecosystem. This process demonstrates that ecosystems have the ability to recover and adapt to environmental changes, although the rate and success are greatly influenced by the initial level of damage and surrounding environmental conditions (Ramdani & Kurniawan, 2023).

Balance in an ecosystem is the result of the complex interactions between biotic and abiotic elements that occur continuously. Under balanced conditions, the amount of energy and matter entering and leaving the ecosystem remains relatively stable, and species populations are at sustainable levels. Major disturbances such as climate change, pollution, or land conversion can shift this balance, leading to ecosystem degradation. Understanding the basic principles of ecosystems is key to designing sustainable environmental management strategies (Amalia & Wibowo, 2020).

The development of modern ecological technology, such as computer-based ecosystem modeling and the use of satellite imagery, enables a more detailed and large-scale analysis of interactions among ecosystem components. This technology helps scientists predict the impacts of environmental changes on ecosystem structure, identify vulnerable areas, and design appropriate interventions. A scientific approach that utilizes ecological data quantitatively

serves as a foundation for formulating conservation policies and integrated natural resource management (Yusuf et al., 2025).

By understanding the basic principles of ecosystems and the interactions between their components, humans can realize that environmental sustainability depends on maintaining harmonious relationships between organisms and their physical environment. This knowledge is crucial to avoid actions that disrupt ecological balance, while also serving as a guideline for creating sustainable environmental management systems for both the present and future generations (Nugraha et al., 2024).

METHODOLOGY

The method used in writing this article is the Qualitative Literature Review. This approach emphasizes the tracing, sorting, and critical synthesis of relevant scientific literature related to ecology and environmental conservation, without employing strict criteria processes like those in a Systematic Literature Review (Sutherland et al., 2018).

The literature analyzed includes research findings, policy reviews, and conceptual articles published in reputable international journals indexed in Scopus and Web of Science since 2016. The search process was conducted using major online databases such as Scopus, Web of Science, and Google Scholar, with keywords encompassing ecology, environmental conservation, climate change, biodiversity, and environmental education (Mngomezulu & Ramaila, 2025).

The stages in the Qualitative Literature Review used include (1) Identifying central themes and contemporary issues in the fields of ecology and environmental conservation; (2) Selecting the most relevant literature based on topic relevance, novelty of findings, and practical and theoretical contributions; (3) Analyzing through in-depth reading and interpretative synthesis of the selected literature content, to build arguments, compare approaches, and integrate new insights; and (4) Preparing a conceptual summary combined with strategic recommendations based on the results of the literature review (Hadi & Afandi, 2021; Ridwan et al., 2021). This method allows the authors to explore various perspectives, summarize knowledge, and enrich the conceptual foundation of the article, thereby creating a comprehensive understanding of the dynamics of ecology and environmental conservation management in the modern era, while highlighting best practices and relevant challenges from various global contexts (Caggiano & Weber, 2023).

RESULTS AND DISCUSSION

1. The Concept and Importance of Environmental Conservation

Environmental conservation is a systematic effort to protect, maintain, and wisely utilize natural resources so they can be used by the current generation without reducing the capacity to meet the needs of future generations. This concept encompasses various actions designed to protect biodiversity, maintain ecosystem functions, and prevent environmental degradation. Conceptually, conservation differs from preservation; conservation emphasizes sustainable use, while preservation leans more toward full protection without human intervention or utilization (Suhendra & Mulyono, 2020).

The history of environmental conservation has developed alongside the growing awareness of the limitations of natural resources and threats to ecosystem sustainability. Initially, conservation was primarily viewed as an effort to preserve resources with economic value, such as forests for timber or fisheries for consumption. The advancement of ecological science has fostered the understanding that every element within an ecosystem is interconnected, meaning the loss of a single component can impact the entire system. This understanding emphasizes that conservation, in addition to economic interests, is also crucial for maintaining overall ecological integrity (Rahayu et al., 2021). The primary goal of conservation is to ensure the sustainability of ecosystem functions, maintain biodiversity, and regulate the utilization of resources in a balanced manner. Biodiversity, whether at the genetic, species, or ecosystem level, plays a vital role in providing ecosystem services that support human life. Forests provide oxygen, regulate the water cycle, and absorb carbon; the oceans provide protein and regulate the global climate. Conservation ensures that these ecosystem services continue to function optimally in the long term (Putra & Iskandar, 2022).

Types of conservation can be distinguished into in-situ and ex-situ. In-situ conservation is carried out in the species' natural habitat, such as national parks, nature reserves, or protected forest areas. This approach is considered effective because it maintains the species along with its ecological interactions. Ex-situ conservation is carried out outside of the natural habitat, such as in zoos, botanical gardens, or gene banks. Although ex-situ does not always maintain natural ecological interactions, this method is important for protecting species that are endangered due to habitat loss (Syamsuddin et al., 2023).

Environmental conservation is also closely related to the concept of sustainable development. The principle of sustainable development emphasizes meeting the needs of the present without compromising the capacity of future generations to meet their own needs. Conservation serves as a foundation to ensure that natural resources are not depleted or damaged to the point of disrupting life sustainability. Integrating conservation into development policies becomes both a challenge and a necessity in the modern era (Wibisono & Kartika, 2020).

The importance of conservation is becoming increasingly prominent amidst various global environmental threats, such as climate change, deforestation, pollution, and the excessive exploitation of natural resources. Climate change affects species distribution, reproductive cycles, and habitat availability. Deforestation leads to the loss of biodiversity while also reducing carbon absorption capacity. Conservation serves as a strategy for mitigating and adapting to these negative impacts (Anggraeni & Yusuf, 2024).

In addition to ecological benefits, conservation also provides social and economic benefits. From a social perspective, conservation preserves resources that are an important part of the culture and identity of local communities, such as customary forests or sacred natural sites. From an economic perspective, conservation supports the ecotourism sector, which provides sustainable income without damaging resources. The utilization of non-timber forest products, such as honey or medicinal plants, is also an example of how conservation can provide economic benefits while still maintaining environmental sustainability (Farhan & Lestari, 2021).

The role of the community in conservation cannot be ignored. The involvement of local communities, especially those living around conservation areas, is key to the success of preservation programs. Communities possess local knowledge and traditional wisdom that can support sustainable management. Community-based conservation programs have been proven effective in increasing compliance with protection regulations and reducing environmental degradation (Hidayah et al., 2022).

Conservation also involves the important roles of governments and international organizations. Governments play a role in establishing regulations, allocating resources, and ensuring law enforcement against environmental violations. International organizations, such as the IUCN or UNEP, provide guidance, funding, and technical support to strengthen conservation efforts in various countries. Cross-border collaboration becomes important, considering that many ecosystems, such as tropical rainforests or oceans, span across national administrative boundaries (Wijaya & Pranoto, 2025).

The aspects of education and public awareness are important components in the success of environmental conservation. Environmental education helps shape eco-friendly behavior from an early age and fosters a sense of responsibility toward nature. Public campaign programs, training, and the integration of conservation material into educational curricula have become widely applied strategies to encourage broad community participation. With high awareness, conservation policies will be more easily accepted and effectively implemented (Zulfikar & Handayani, 2023).

Environmental conservation is an urgent necessity in the modern era, characterized by increasing ecological pressures. Without conservation, the sustainability of ecosystems and the survival of humans are seriously threatened. The concepts and practices of conservation must continue to be developed, supported by strong policies, advanced scientific knowledge, and the active involvement of all stakeholders. Conservation is not merely the responsibility of the government or environmental organizations, but a collective responsibility of

all humanity to ensure the Earth remains habitable for current and future generations (Pramudita & Nugroho, 2024).

2. Challenges and Conservation Strategies in the Modern Era

Environmental conservation in the modern era faces dynamics that are far more complex compared to several decades ago. Technological advancements, population growth, and globalization accelerate socio-economic changes that have direct and indirect impacts on the preservation of nature. The challenges that arise are not only ecological but also political, social, and economic, all interrelated in influencing the success of conservation efforts. Experts describe this era as a period of 'planetary change,' marked by the accelerated degradation of ecosystems globally due to human activities (Liu et al., 2021). Conservation strategies, in addition to relying on traditional approaches, also need to be adapted to new challenges that emerge with the progression of time.

The greatest conservation challenge in the modern era is global climate change. The rise in the Earth's average temperature, shifts in rainfall patterns, and increasing frequency of natural disasters such as floods, droughts, and tropical storms affect species distribution and ecosystem stability. Studies show that climate change has caused habitat shifts for thousands of species worldwide, forcing them to migrate to more suitable areas or face the risk of extinction (Chen et al., 2020). This poses a significant challenge for conservation programs, as previously protected habitats may no longer be suitable for target species.

In addition to climate change, deforestation and land degradation remain serious threats. The rate of conversion of natural forests into agricultural land, plantations, and residential areas is increasing rapidly, especially in developing countries. Deforestation not only reduces biodiversity but also exacerbates the impacts of climate change through the release of carbon stored in vegetation and soil. Although reforestation efforts have been made in various regions, the global rate of deforestation still surpasses the success of forest replanting (Curtis et al., 2021). This indicates that conservation policies must integrate the protection of primary forests with the sustainable management of degraded land.

Another challenge is environmental pollution, including air, water, and soil pollution. The increased use of synthetic chemicals, industrial waste, and single-use plastics has worsened environmental quality. Microplastics have been found in almost every ecosystem in the world, including in deep-sea waters, remote mountains, and even in the human body (Barboza et al., 2021). This pollution not only endangers human health but also disrupts ecosystem functions and threatens the survival of various species. Addressing pollution challenges requires conservation strategies integrated with waste management policies and pollution control (Pambudi & Pramujo, 2025).

Globalization also brings new challenges in the form of the spread of invasive species that threaten local biodiversity. International trade, tourism, and changes in land use have accelerated the movement of species across regions. Invasive species often have high adaptive capacity, are able to dominate new habitats, and replace native species. As a result, ecosystem balance is disrupted, and even ecosystem functions can experience drastic declines. Biological

invasions have become one of the main causes of global biodiversity loss after land-use changes and overexploitation (Bellard et al., 2020).

In addition to ecological challenges, conservation also faces conflicts of interest between economic development and environmental preservation. Many large-scale development projects such as mining, infrastructure, and agricultural expansion collide with conservation areas. Although economic development is important for community welfare, if carried out without careful ecological planning, its impacts can be highly damaging. This conflict is often exacerbated by weak environmental law enforcement, corruption, and lack of public awareness (Sharma et al., 2022).

In facing these various challenges, a conservation strategy based on science and multi-stakeholder collaboration is required. This strategy includes the continuous collection of ecological data, modeling the impacts of climate change, and developing adaptation plans for vulnerable species and ecosystems. The use of technologies such as satellite imagery, drones, and automated monitoring systems has proven effective in tracking real-time environmental changes. This data-driven approach enables faster and more accurate decision-making in managing conservation areas (Turner et al., 2021).

In addition to technological approaches, local wisdom and community participation play a key role in the success of conservation. Local communities living around conservation areas often possess traditional knowledge about the ecosystems they inhabit (Sinthumule, 2023). Integrating local knowledge with modern science can produce more effective and sustainable conservation strategies. For example, customary forest systems in various regions have been shown to be able to maintain biodiversity while also providing livelihoods for the communities (Kariuki et al., 2020).

Education and increasing public awareness are also important strategies. Conservation will not succeed if it is solely the responsibility of the government or scientists; rather, it must involve all layers of society. Environmental education programs in schools, social media campaigns, and volunteer activities in nature can enhance the sense of care and shared responsibility (Mngomezulu & Ramaila, 2025). Research shows that high environmental awareness in the community can drive significant behavioral changes, such as reducing plastic use and supporting environmentally friendly policies (Sanchez et al., 2021).

In the modern era, international cooperation is becoming increasingly important given that many conservation challenges are transboundary in nature, such as wildlife migration, marine pollution, and climate change. International conventions such as the Convention on Biological Diversity (CBD) and the Paris Agreement serve as platforms for global coordination in conservation efforts. Countries around the world need to strengthen their commitments to achieving conservation targets, including expanding protected areas and reducing threats to endangered species (Zhou et al., 2022).

With the various challenges and opportunities present, conservation in the modern era requires an adaptive, collaborative, and evidence-based approach. Combining advanced technology, local wisdom, strong policies, and public awareness will form a solid foundation for long-term environmental

preservation (Sinthumule, 2023). The success of conservation is not only to maintain biodiversity but also to ensure the sustainability of human life on this planet.

CONCLUSIONS

This article has comprehensively discussed the role of ecology as a fundamental science that is crucial in environmental conservation efforts in the modern era. The study begins with a fundamental understanding of ecological concepts – ranging from levels of life organization, biotic and abiotic interactions, to a multidisciplinary scope that includes social, economic, and cultural dimensions. Furthermore, the article reviews how ecological knowledge serves as a critical scientific foundation in evaluating the impact of human activities, designing natural resource management strategies, and implementing spatial planning and conservation policies.

The utilization of the latest technologies such as remote sensing, ecosystem modeling, and spatial data analysis has been proven to enhance the effectiveness of ecosystem monitoring and restoration. A holistic ecological approach, integrating scientific, social, cultural, and public policy perspectives, is an essential requirement in addressing challenges such as ecosystem degradation, climate change, invasive species, and the conflict between development and conservation. In addition, active community participation, the integration of traditional knowledge, and the enhancement of collective awareness through environmental education are presented as key factors for the successful sustainable conservation of ecosystems.

This study also highlights the major conservation challenges in the era of globalization and climate change, such as shifts in species habitats, the intensification of pollution (especially microplastics), and the threat of biodiversity loss. Although conservation efforts are increasingly advancing – through international collaboration, government regulations, and technological innovations – their implementation on the ground still faces multifaceted obstacles, ranging from limited resources and conflicts of interest to weak enforcement of environmental laws.

On the other hand, the literature review results affirm that a dynamic and adaptive ecological approach, supported by thematic and interdisciplinary analysis, can help formulate concrete solutions for ecosystem preservation. Early environmental education, strengthening the role of local communities, and integrating continuous monitoring data are strategies that must be continuously expanded to build ecosystem resilience against change and anthropogenic pressures

RECOMMENDATIONS

Follow-Up Research Recommendations

1. Longitudinal Research on the Integration of Traditional Knowledge and Modern Technology

Further studies are needed to develop collaborative models between local/traditional knowledge and modern ecological technology, particularly in the conservation of critical habitats and community-based resource management.

2. Analysis of Policy Effectiveness and Conservation Management Implementation

It is recommended to conduct a systematic evaluation of government and international agency policies related to conservation, including studies on factors that encourage or hinder the enforcement of regulations at the field implementation level.

3. Development of Community-Based Environmental Education Models

Research is needed on how community-based environmental education can foster sustainable conservation behaviors and ethos, as well as enhance the socio-ecological resilience of local communities.

4. Utilization of Big Data and Remote Sensing for Ecosystem Monitoring

Research on machine learning and artificial intelligence algorithms in satellite data analysis is crucial to accelerate early detection of ecosystem degradation and strengthen data-driven spatial decision-making.

5. Study of the Impact of Socio-Ecological Systems on Ecosystem Resilience

Interdisciplinary research that examines the relationships between social, economic, political, and ecological aspects in shaping ecosystem resilience needs to be continuously developed in order to produce more effective and contextual policy frameworks.

By advancing the aforementioned research, it is hoped that the scientific foundation and ecological-based environmental conservation practices can be further strengthened and remain relevant in facing future planetary challenges.

FURTHER STUDY

This research still has limitations so that further research is needed on the topic of Ecology as the Foundation of Conservation Transformation to perfect this research and increase insight for readers and writers.

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