A Qualitative Study on the need to Formulate Policies for the Sustainable use of Biodiversity in the Face of Current Conservation Challenges (Special Reference to Sinharaja Rainforest)

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Abstract: The Sinharaja Rainforest is a controversial ecosystem as one of the most important ecological regions in the world. It has been named a biodiversity hotspot in the world because of its high biodiversity and many environmental values. The Sinharaja Forest, which is a protected forest, is also an ecological region used for the tourism industry. Therefore, sustainable use should be emphasized over conservation. What should be the strategies to access the sustainable use and development of the biodiversity that needs to be conserved? The research was conducted with the aim of studying the possibilities of accessing the sustainable use and development of the biodiversity that needs to be conserved in relation to the research question. Using a mixed research methodology, primary data was collected through field studies, interviews, and unstructured discussions led by questionnaires in the Sinharaja Forest, and secondary data was collected through research articles, newspapers, and the Internet. The data was analyzed using Excel software and Excel software was used for data visualization. After analyzing the data, it was concluded that community awareness regarding sustainable use and conservation is at a very low level and that new strategic plans should be adopted by giving priority to sustainability in policy planning.

Keywords: Environment, Conservation, Sustainable Use, Policy, Sustainable Development

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Introduction

The Sinharaja Forest Reserve, a UNESCO World Heritage Site located in the southwest of Sri Lanka, is one of the most treasured natural habitats in the world. The name "Sinharaja" translates to "Lion King" in Sinhala, hinting at its majestic status. This tropical rainforest dates back millions of years and represents a remnant of Sri Lanka's ancient ecosystems. Believed to be part of the Gondwanaland supercontinent, the forest's biodiversity and ecological significance make it a vital area for conservation. Sinharaja spans approximately 11,187 hectares and lies in the lowland wet zone, straddling the Galle, Matara, and Ratnapura districts. Its terrain is rugged, with a series of ridges and valleys that vary in altitude between 200 to 1,170 meters above sea level. The forest is bordered by several rivers, including the Gin Ganga to the south and the Kalu Ganga to the north, with tributaries and streams crisscrossing its interior. These water bodies not only sustain the forest's diverse species but also contribute to the livelihoods of surrounding communities. The topography, marked by steep slopes and dense undergrowth, contributes to the difficulty of accessing the deeper parts of the forest. However, it also ensures the survival of species that might otherwise face threats from human activity. The undulating landscape creates a range of microhabitats, each supporting different forms of life. Sinharaja's biological diversity is unparalleled. The forest is home to over 830 endemic species of flora and fauna, including trees, amphibians, reptiles, birds, and insects. Approximately 60% of the trees found in Sinharaja are endemic to Sri Lanka, with species like Shorea stipularis and Dipterocarpus zeylanicus dominating the canopy. The forest also supports a rich variety of fauna. It is particularly renowned for its birdlife, serving as a haven for endemic species such as the Sri Lanka blue magpie (Urocissa ornata), Sri Lanka hanging parrot (Loriculus beryllinus), and the red-faced malkoha (Phaenicophaeus pyrrhocephalus). Mammals like the purple-faced langur and Sri Lankan leopard are occasionally spotted, while smaller creatures such as amphibians and reptiles thrive in the moist environment. The diversity of Sinharaja extends beyond visible wildlife. The forest is a genetic repository of immense value, hosting unique plant species that have medicinal and ecological importance. Its interconnected ecosystems ensure a continuous cycle

of nutrient recycling, water filtration, and climate regulation. Sinharaja's climate is characterized by high humidity, consistent rainfall, and warm temperatures. Situated in a wet zone, the forest experiences an annual rainfall ranging from 3,000 to 6,000 millimeters. Rainfall is evenly distributed throughout the year, with two main monsoon seasons—the southwest monsoon from May to September and the northeast monsoon from November to February. The average temperature ranges between 18°C to 27°C, making it conducive for tropical flora and fauna. The constant presence of mist and high humidity levels, often exceeding 75%, enhances the growth of epiphytes, ferns, and mosses. These climatic conditions also make Sinharaja an essential water catchment area, supporting both the forest ecosystem and the surrounding human settlements.

Research Problem

In the development evolution, various strategies are created to update the future existence of the world. Considering the usefulness of those strategies, developed countries quickly start using them for their countries. However, for developing countries and poor countries, new concepts have to be used only after decades of the emergence of those concepts due to various reasons. After the advent of conservation, development, then development with conservation, then sustainable development and sustainable use are the leading concepts used in the world. This research problem was created due to the main need to operate these concepts from a high diplomatic level and to increase the low level of knowledge about sustainable use in Sri Lanka.

What should be the strategies to approach the sustainable use and development of biodiversity to be conserved..?

Research Objectives

Conservation and sustainable use are not just conceptual concepts, but rather the different benefits that exist and the utility of bringing them to the community. The aim is to understand & identify the importance of conservation and sustainable use policies and their long-term benefits in planning environmental policies.

Significance of the Study

Biodiversity is the foundation of life on Earth, encompassing the variety of species, ecosystems, and genetic resources that sustain human well-being. Its sustainable use is crucial for maintaining ecological balance, supporting economic activities, and ensuring food and health security. The study of the need to formulate policies for sustainable biodiversity use is essential for addressing the current environmental challenges and securing the benefits biodiversity provides for future generations. One key significance of this study lies in its ability to guide decision-making processes to prevent biodiversity loss. Unsustainable practices such as deforestation, overfishing, and habitat destruction have led to alarming rates of species extinction. By identifying the drivers of biodiversity decline, such research informs the creation of targeted policies to mitigate these threats. Such policies ensure the conservation of ecosystems while allowing their resources to be utilized in ways that do not compromise their regeneration.

Another critical aspect is the role of biodiversity in supporting livelihoods, particularly for communities that directly depend on natural resources. Sustainable biodiversity policies can help establish frameworks for equitable resource sharing and promote practices like agroforestry, ecotourism, and community-managed conservation areas. These approaches not only safeguard ecosystems but also contribute to poverty alleviation and economic development. Additionally, biodiversity is integral to climate change mitigation and adaptation. Healthy ecosystems, such as forests and wetlands, act as carbon sinks and buffers against natural disasters. Policies promoting the sustainable use of biodiversity can enhance ecosystem resilience, reduce vulnerabilities to climate impacts, and align with global commitments like the Paris Agreement and the Sustainable Development Goals (SDGs).

Furthermore, studying the need for biodiversity policies fosters international cooperation. Biodiversity transcends national boundaries, and its preservation requires collaborative efforts. Research can facilitate the development of international agreements, such as the Convention on Biological Diversity (CBD), to ensure shared responsibility for global biodiversity conservation. Finally, the study highlights the ethical dimension of biodiversity stewardship.

All species have intrinsic value, and humanity has a moral obligation to ensure their survival. Policies based on this principle encourage a holistic approach to biodiversity management, integrating scientific knowledge with traditional and indigenous wisdom. In conclusion, the study of the need to formulate policies for the sustainable use of biodiversity is vital for balancing ecological preservation with human development. It provides the foundation for creating strategies that protect biodiversity while enabling societies to thrive sustainably, ensuring a harmonious coexistence between humans and nature.

Discussions about development began after Harry Truman's speech in 1949. There, theories about development and underdevelopment emerged. But theories about conservation were formed before the 18th century. This conservation concept, which first emerged, spread rapidly throughout the world. One reason for this was that destruction was very strong throughout industrialization and the relative lack of conservation methods. After that, although various concepts came to the world, conservation emerged in a more powerful way.

Literature Review

The sustainable use of biodiversity is a central pillar in achieving global conservation goals, particularly under frameworks like the Convention on Biological Diversity (CBD). Biodiversity is the foundation for ecosystem services, contributing to food security, climate resilience, and economic stability. However, current conservation challenges such as habitat destruction, climate change, overexploitation, and invasive species demand an integrated approach to sustainable use. This review synthesizes key literature to provide an overview of strategies for sustainable biodiversity use amidst these challenges. The sustainable use of biodiversity is critical for maintaining ecological balance and ensuring the continued availability of natural resources for future generations. According to Mace et al. (2012), sustainable practices can mitigate biodiversity loss by aligning human activities with ecological limits. For instance, sustainable forestry practices help preserve ecosystem integrity while supporting local livelihoods (Parrotta et al., 2012). Similarly, agroecological systems that promote biodiversity enhance soil health and crop yields, reducing reliance on chemical inputs (Altieri, 1999).

Conservation Challenges and Sustainable Use Strategies

Habitat destruction, driven by urbanization, agriculture, and infrastructure development, is a primary driver of biodiversity loss. According to Newbold et al. (2016), land use changes have led to significant declines in species richness across biomes. To counteract this, the adoption of landscape-level conservation approaches has been recommended. For example, the concept of ecological corridors links fragmented habitats, facilitating species migration and genetic exchange (Hilty et al., 2020). Protected areas (PAs) are another cornerstone of biodiversity conservation. However, a study by Watson et al. (2014) highlights that PAs often face resource constraints and human encroachments. To address these issues, community-based conservation models that integrate local stakeholders in management decisions have shown promise (Berkes, 2004).

Climate change exacerbates biodiversity loss through shifts in species distributions, altered ecosystem dynamics, and increased extinction risks. Parmesan and Yohe (2003) document widespread changes in phenology and range among species due to climate warming. Adaptive management strategies, such as assisted migration and habitat restoration, are emerging as critical tools to combat these effects (Hoegh-Guldberg et al., 2008). Nature-based solutions (NbS), which harness ecosystem functions to address societal challenges, offer dual benefits for biodiversity and climate mitigation. Mangrove restoration, for instance, sequesters carbon while protecting coastal biodiversity (Macintosh et al., 2012). Overexploitation of biological resources, including overfishing, logging, and wildlife trade, poses significant threats to biodiversity. Pinsky et al. (2014) highlight that unsustainable fishing practices have led to declines in marine populations and ecosystem imbalances. Regulatory measures, such as quota systems and community-managed fisheries, have been effective in promoting sustainable use. Certification schemes like the Forest Stewardship Council (FSC) and Marine Stewardship Council (MSC) also play a role in encouraging sustainable resource use (Gulbrandsen, 2006). Invasive alien species (IAS) disrupt native ecosystems, often leading to the displacement or extinction of indigenous species. Globalization and trade are key drivers of IAS introductions (Pyšek et al., 2010).

Early detection and rapid response systems are critical for managing IAS impacts. Additionally, public awareness campaigns and international collaborations, such as the Global Invasive Species Programme (GISP), have been instrumental in addressing this issue.

Global policy frameworks provide a foundation for integrating sustainable use and conservation. The Aichi Biodiversity Targets and the Post-2020 Global Biodiversity Framework emphasize sustainable use as a core component of biodiversity conservation (CBD, 2020). These frameworks advocate for mainstreaming biodiversity into sectoral policies, fostering cross-sectoral collaboration. Effective governance mechanisms are crucial for implementing sustainable practices. Ostrom's (1990) principles for managing common-pool resources emphasize the importance of local governance, equitable benefit-sharing, and adaptive management. Additionally, multi-level governance approaches that involve national, regional, and local stakeholders enhance policy coherence and implementation efficiency (Paavola et al., 2009).

Definition Overview

The concept of "conservation" is fundamental in environmental science and policy, often defined as the sustainable management of natural resources to maintain biodiversity, ecosystem services, and overall ecological balance. Conservation is an interdisciplinary field that spans ecology, economics, and policy, aiming to prevent degradation of ecosystems and species loss, and to ensure that future generations can benefit from nature's resources. In a broad sense, conservation is defined as the preservation, protection, management, or restoration of natural environments and wildlife (Leroux et al., 2017). It involves various strategies, including habitat protection, sustainable resource use, and restoration of degraded ecosystems. The goal is to conserve biodiversity—defined as the variety of life forms within a given ecosystem—and to maintain the resilience of ecosystems that provide critical services such as clean water, air, and climate regulation (Chapin et al., 2000). From a more specific perspective, conservation can be seen as the application of scientific principles to manage human interactions with nature to promote sustainability. For instance, the concept of "in situ conservation" refers

to protecting species and habitats in their natural environments, whereas "ex situ conservation" involves the preservation of species outside their natural habitat, such as in zoos or seed banks (IUCN, 2014). Environmental policy also plays a crucial role in conservation. The concept of conservation in policy planning often includes balancing ecological preservation with human development needs. It involves strategies such as conservation easements, sustainable forestry practices, and community-based conservation initiatives that empower local communities to manage their natural resources sustainably (Berkes, 2004). Thus, the conservation concept encompasses a broad range of activities, from protecting species to managing ecosystems for the benefit of both nature and humanity. It requires interdisciplinary approaches to address the complex challenges of environmental degradation and biodiversity loss.

The concept of "sustainable use" is integral to environmental management and conservation, emphasizing the responsible use of natural resources to meet present needs while ensuring their availability for future generations. The World Conservation Strategy first introduced the term in 1980, highlighting the importance of maintaining ecological processes and life-support systems, conserving genetic diversity, and ensuring sustainable utilization of species and ecosystems (IUCN, 1980). At its core, sustainable use involves balancing human demands with ecological integrity. This concept has been elaborated in various international frameworks, such as the Convention on Biological Diversity (CBD), which defines sustainable use as "the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations" (CBD, 1992). In practice, sustainable use necessitates a multi-faceted approach encompassing scientific research, traditional knowledge, policy-making, and community involvement. For example, fisheries management integrates sustainable use principles by regulating harvest levels to prevent overexploitation, ensuring biodiversity conservation, and sustaining livelihoods dependent on marine resources (FAO, 2020). Similarly, sustainable agricultural practices, such as crop rotation and organic farming, aim to balance productivity with soil and ecosystem health. Despite its broad acceptance,

achieving sustainable use remains challenging due to competing economic, social, and political interests. Critics argue that the term's ambiguity sometimes leads to inconsistent application, undermining its effectiveness (Redford & Sanderson, 2000). Nonetheless, sustainable use is critical for achieving global sustainability goals, such as the United Nations' Sustainable Development Goals (SDGs), particularly SDG 12 on responsible consumption and production.

Research Methodology

The deductive approach develops theory and builds a hypothesis (Creswell, 2014). This is a research conducted through the Deductive research methodology. In order to fulfill the primary objective of "studying strategies to approach the sustainability and development of biodiversity", about 2 km2 of Sinharaja forest was primarily studied. Also, every organism found randomly was studied without classification.

Method of Data Collection

The Sinharaja forest was the main focus of the study.Its secondary and primary forests were studied as primary. There, the biodiversity found randomly in 2km2 areas covering the secondary and primary forests was studied. The Sinharaja field study was conducted over three days, May 23, 24 and 25, 2024. During the three days, the field study was conducted from 5 am to 6 pm, and then the night biodiversity field study was conducted from 8.00 pm to 11.00 pm.50 individuals involved in the field study were also contacted for unstructured questionnaire-based discussions.

In addition to the field study, interviews were conducted as a primary data collection method. Discussions were conducted with two tour guides and an environmental researcher in the field.

Secondary sources were also used for the study. For this purpose, research reports, reports, presentations on the Sinharaja Forest, reports on policy planning, socio-political reports, environmental management reports, etc., related books and newspapers, etc. were consulted.

Data Analysis & Interpretation

Excel software was used to analyze primary data obtained through field studies, interviews and secondary data obtained through sources. MS Word software was used to analyze data obtained through research sources. Excel software was used to visualize data.

Results & Findings

Findings from Field Observation

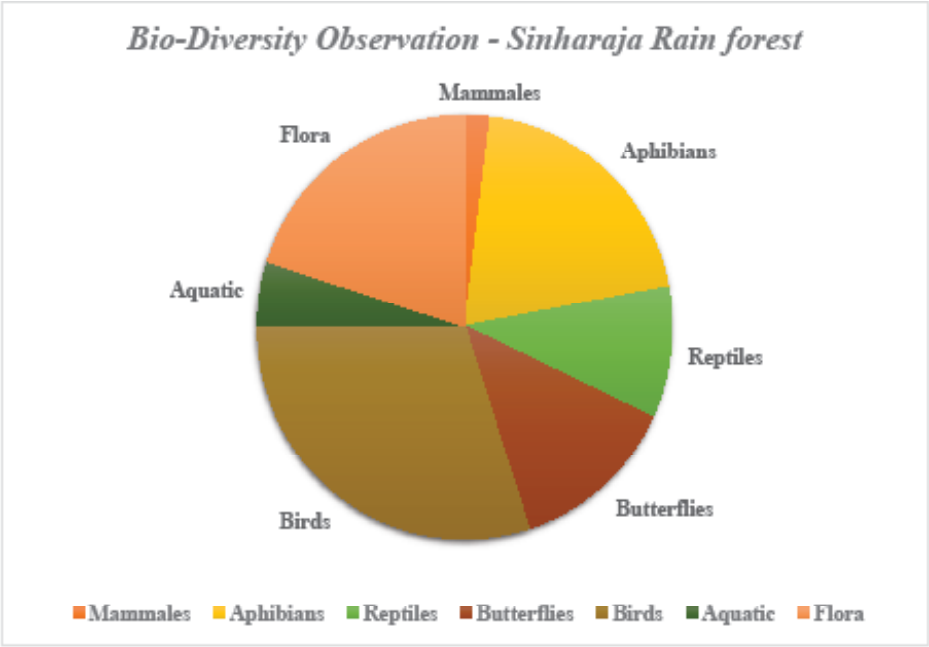
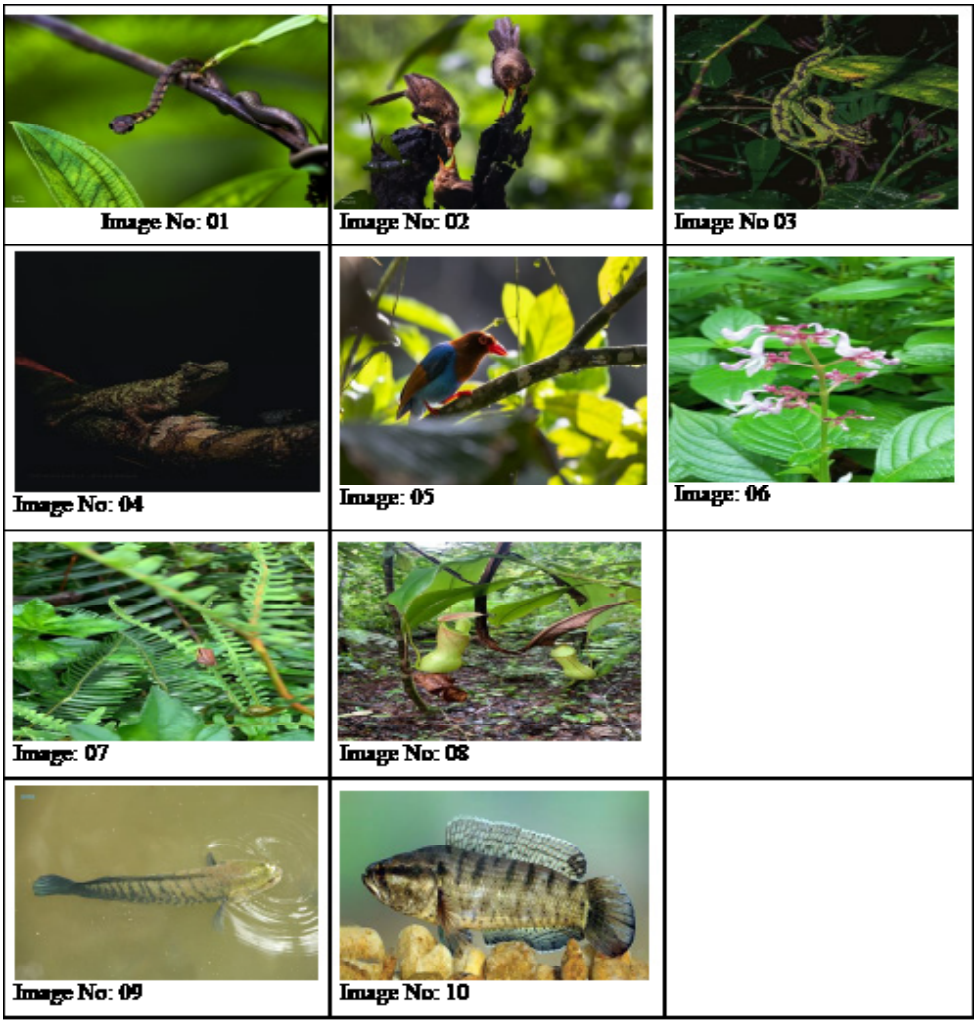


Figure 01: Bio-Diversity Observation Analysis
Source: Field Survey

Through field observations, the biodiversity of the Sinharaja Rainforest was observed over a period of three full days as shown in Chart No. 01 below. Mammals, reptiles, butterflies, birds, fish, amphibians and plants were studied.

Identified Mammals Species are Semnopithecus Velutus (Sri lanka Perple faced Monkey), Pathera Pardus Kotiya (Srilanka Leopard). Amphibians are Nannophrys ceylonensis (Sri lanka Rock Frog), Polypedetes longinasus (Southern whipping frog), Pseudophaullus popularis (Common shrub frog), Pseudophaullus

Folicola. Reptiles are Lyriocephalus scutatus (Lyres head lizard), Otocryptis wiegmanni (Wet zone kangaroo lizard), Trimeresurus trigonocephalus (Green pit Viper), Oxybelis aeneus (Brown wine snake), Boiga Ceylonensis (Sri lanka Cat snake). Birds are Phaenicophaeus pyrrhocephalus (Red faced malkoha), Dicrurus lophorinus (Sri lanka drongo), Urocissa ornate (Sri lankan Blue Magpie), Argya cinereifrons (Ashy-headed laughingthrush), Harpactes fasciatus (Malabar trogon), Turdoides rufescens (Orange Billed Babbler), Pomatorhinus melanurus (Sri lanka scimitar babbler). Butterflies are Troides darsius (Sri lanka Birdwing), Idea iasonia (Ceylon tree nymph), Pachliopta jophon (Sri lanka Rose), Papilio helenus (Red Helen), Parthenos sylvia (Clipper). Aquatics are Channa Striata (Striped snakehead), Channa Pucntata (Spotted snakehead)



Source: Findings from Field Observation

Findings from interviews with tourism industry experts

These two scholars are foreign tour guides and field researchers in the tourism sector. They were interviewed separately and asked about the basic concepts related to the study and the common ideologies of both local and foreign nationals they encounter in the field. If 100 people were interviewed in a month, a summary of their understanding of conservation, understanding of sustainable use, understanding of sustainable development, and understanding of the importance of policy planning is shown in the graph below.

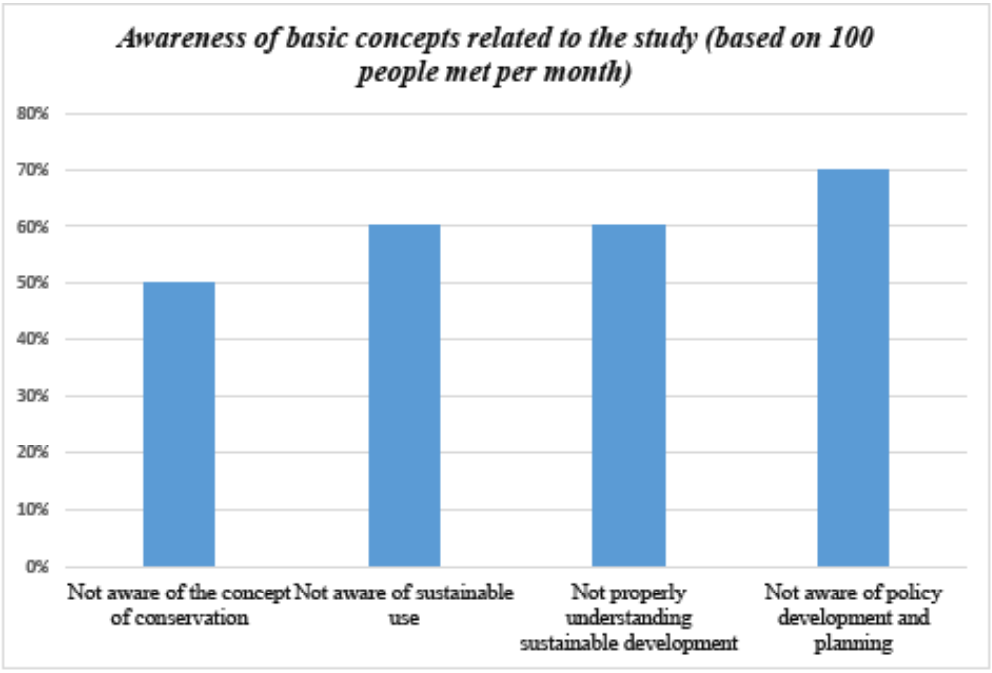


Figure 02: Awareness of Basic Concepts Related to the Study
Source: Created by Researcher based on Interview data

There are many protected areas in Sri Lanka in relation to the land area. Another fact is that Sri Lanka is a country located in the intertropical convergence zone, so it is a region with a very high biodiversity. Since the government has the administrative powers over all these areas in such a country, there is a large number of subject areas to be considered in the development of these areas. The formulation of conservation strategies as well as the formulation of strategies that are widely used in the world are also very timely.

When connecting the tourism industry and environmental studies, the need for very timely and spatially-based policy formulation has emerged very strongly in the present day, when using very delicate and sensitive areas and making financial arrangements. Demand in the tourism sector is largely created by specializing in each field. It is a field update compared to the situation about 10 years ago. For example, the number of people who come to study the environment has increased rather than seeing its beauty. There are fields such as environment, biodiversity, research, cultural potential, sustainable use, etc. Then, it has been possible to identify through primary data that it is very difficult to visit and study a large part of the environment with the current conservation policies.

Findings from Field Study Individuals, unstructured questionnaire-based discussions.

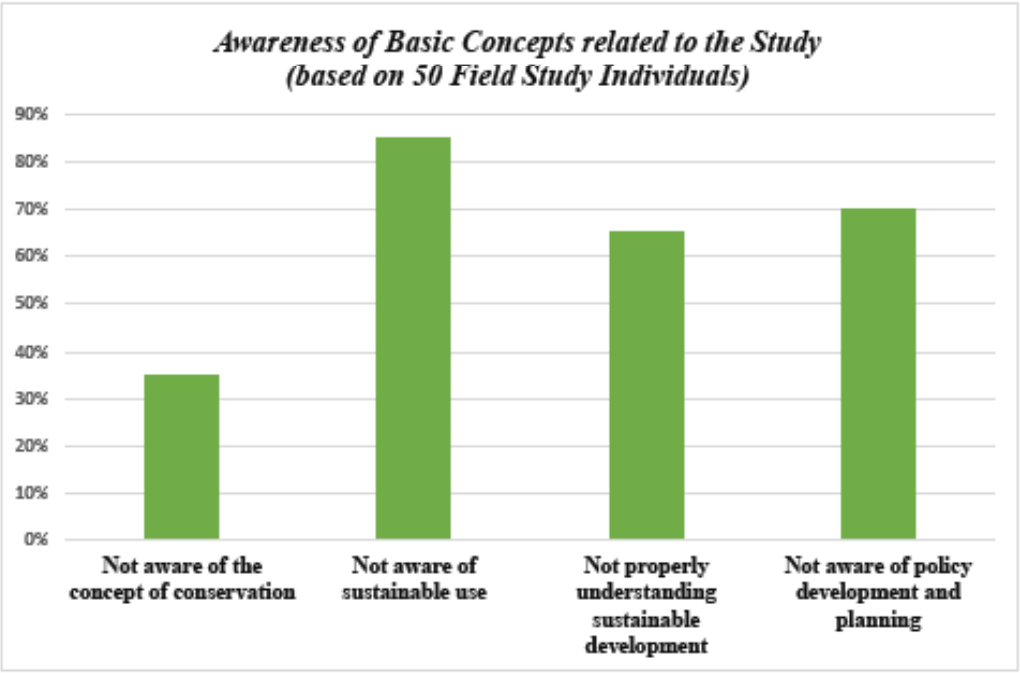


Figure 03: Awareness of Basic Concepts Related to the Study

Source: Created by Researcher based on unstructured questionnaire-based discussion data

Most of the people involved in the field study are graduates and scholars, and a very small number are employed without having completed O/L, A/L and higher education. However, they are a group that has a very high understanding of the environment and biodiversity, including the naming and identification of organisms and environmental sensitivities. The understanding of basic concepts related to the study was investigated among this group.

Findings from Secondary Research Analysis

Biodiversity conservation remains a critical global challenge, essential for maintaining ecosystem services, sustaining livelihoods, and ensuring ecological balance. Scientists have made significant strides in understanding the drivers of biodiversity loss and proposing innovative strategies for conservation. This review synthesizes recent research findings, highlighting key trends and actionable insights. Recent studies confirm that habitat destruction, climate change, invasive species, pollution, and overexploitation are the primary drivers of biodiversity decline (IPBES, 2019). Habitat fragmentation, driven by deforestation and urbanization, disrupts ecological connectivity, leaving species vulnerable to extinction. For instance, the Amazon rainforest, a critical global biodiversity hotspot, has seen a 20% reduction in its area due to deforestation, threatening countless species (Barlow et al., 2020).Climate change exacerbates these threats by altering habitats and forcing species to migrate or adapt rapidly. Research by Parmesan et al. (2022) shows that rising temperatures have led to phonological mismatches, such as plants blooming earlier than their pollinators are active, reducing reproductive success.

Scientists emphasize the need for integrated conservation approaches that combine in-situ and ex-situ methods. Protected areas remain the cornerstone of biodiversity conservation, yet their effectiveness hinges on sound management and enforcement. A global meta-analysis by Visconti et al. (2021) reveals that well-managed protected areas can increase species survival rates by up to 40%. In addition, community-based conservation has gained traction, particularly in developing regions. These programs, which involve local communities in the stewardship of natural resources, have demonstrated success in conserving biodiversity while improving livelihoods. For example, Ostrom et al. (2021)

highlighted the role of indigenous communities in the Amazon in preserving 60% more forest cover than state-protected reserves. Technological innovations are also transforming conservation practices. Remote sensing, artificial intelligence, and environmental DNA (eDNA) are enhancing biodiversity monitoring and species identification. eDNA has proven particularly valuable in detecting elusive or endangered aquatic species, such as the critically endangered Mekong giant catfish (Roberts et al., 2023). The Convention on Biological Diversity (CBD) and its Kunming-Montreal Global Biodiversity Framework (2022) emphasize ambitious targets, such as protecting 30% of Earth's land and oceans by 2030. Achieving these goals requires substantial financial investments, estimated at $700 billion annually (CBD, 2022). A recent report by Dasgupta (2021) underscores the economic rationale for biodiversity conservation, framing it as an essential investment for long-term human and planetary well-being.

Scientists also advocate for cross-sectoral collaboration, integrating biodiversity considerations into agriculture, urban planning, and trade policies. A study by Benton et al. (2022) illustrates how agroecological practices, such as intercropping and reduced pesticide use, can enhance biodiversity on farmlands while maintaining productivity. The conservation of biodiversity demands urgent, multi-faceted efforts informed by scientific research. While significant progress has been made, bridging the implementation gap remains a challenge. Collaborative action, technological advancements, and community engagement are vital to safeguarding Earth's biodiversity for future generations.

Despite progress, significant challenges remain in operationalizing sustainable use strategies. Limited financial and technical resources constrain conservation efforts, particularly in developing countries (Fisher et al., 2012). Conflicts between conservation goals and economic development further complicate implementation. For example, large-scale infrastructure projects often prioritize economic gains over biodiversity protection (Laurance et al., 2015). Scientific and traditional knowledge integration is another area requiring attention. While scientific research provides data-driven insights, traditional ecological knowledge (TEK) offers context-specific understanding of ecosystems. Collaborative approaches that respect and integrate TEK can enhance conservation

outcomes (Gadgil et al., 1993).

Community-Based Natural Resource Management (CBNRM) in Namibia: Namibia's CBNRM program has successfully combined biodiversity conservation with economic benefits for local communities. Through communal conservancies, local people manage natural resources sustainably, leading to increased wildlife populations and tourism revenue (NACSO, 2010). Agroforestry Systems in the Amazon: Agroforestry practices in the Amazon integrate tree planting with agricultural activities, preserving biodiversity while supporting livelihoods. These systems enhance carbon sequestration and provide habitats for various species (Schroth et al., 2004). Marine Protected Areas (MPAs) in the Philippines: The Philippines has established MPAs to address overfishing and habitat degradation. Studies show that well-managed MPAs lead to increased fish biomass and coral reef health, benefiting both biodiversity and local fisheries (Alcala et al., 2005).

Strengthening Financial Mechanisms: Innovative financing models, such as payment for ecosystem services (PES) and biodiversity offsets, can provide resources for conservation initiatives (Wunder, 2007). Enhancing Monitoring and Evaluation: Robust monitoring systems are essential for assessing the effectiveness of sustainable use strategies. Advances in remote sensing and citizen science offer new opportunities for biodiversity monitoring (Pettorelli et al., 2014). Promoting Inclusive Conservation: Ensuring the participation of marginalized groups, including indigenous peoples and women, can enhance the equity and effectiveness of conservation programs (Agrawal & Redford, 2009). Scaling Up Nature-Based Solutions: Expanding NbS implementation can simultaneously address multiple conservation and development objectives. For instance, urban green spaces can enhance biodiversity while improving human well-being (Elmqvist et al., 2013).

The sustainable use of biodiversity is indispensable for addressing current conservation challenges. Integrating ecological, social, and economic dimensions in conservation planning is essential for achieving long-term sustainability. By leveraging innovative strategies, inclusive governance, and robust policy frameworks, the global community can navigate the complexities of biodiversity conservation in the face of ongoing threats. Continued research, collaboration, and adaptive management will be crucial in realizing this vision.

Biodiversity conservation has emerged as a critical concern globally due to escalating threats such as habitat loss, climate change, invasive species, and overexploitation of resources. Effective policy planning is central to addressing these challenges, as it provides structured approaches to protect ecosystems and species. This review synthesizes key findings from recent research on biodiversity conservation policy planning, focusing on frameworks, challenges, and opportunities

Recent studies emphasize the importance of integrated frameworks that combine ecological, social, and economic dimensions in biodiversity policy planning. For instance, the Ecosystem-based Management (EBM) approach has been highlighted as a holistic method that balances conservation with sustainable use of natural resources. The integration of spatial planning tools, such as Geographic Information Systems (GIS), facilitates the identification of critical biodiversity hotspots and areas requiring protection (Margules & Pressey, 2000). Moreover, the Convention on Biological Diversity (CBD) has provided a global framework through the Aichi Biodiversity Targets, urging nations to adopt national biodiversity strategies and action plans (NBSAPs).

Policy planning for biodiversity conservation faces several obstacles. A significant issue is the lack of sufficient data on species distribution and ecosystem services, which hampers informed decision-making (Mace et al., 2010). Additionally, conflicts between conservation goals and economic development often lead to policy trade-offs. For example, expanding agricultural activities and urbanization frequently result in habitat fragmentation, undermining conservation efforts. Political will and funding limitations further exacerbate these challenges, particularly in developing countries where resources for implementation and enforcement are scarce (McCarthy et al., 2012).

Research underscores the necessity of involving multiple stakeholders in biodiversity conservation policies, including local communities, policymakers, scientists, and private sectors. Collaborative governance models, such as co-management, have proven effective in fostering shared responsibility and integrating traditional knowledge into modern conservation strategies (Berkes, 2009). For instance, community-based natural resource management (CBNRM) in Africa has demonstrated success in aligning local livelihoods with conservation

goals.

Innovative approaches in policy planning, such as Payment for Ecosystem Services (PES) and biodiversity offsets, offer promising avenues for funding and incentivizing conservation (Wunder, 2005). Technological advancements, including remote sensing and artificial intelligence, enable more accurate monitoring of biodiversity and predictive modeling of conservation outcomes. The recognition of nature-based solutions (NbS) in international policies, such as the Paris Agreement, has further integrated biodiversity conservation into climate change mitigation strategies Policy planning for biodiversity conservation is at a critical juncture, with a need for adaptive, evidence-based, and participatory approaches to address pressing challenges. While frameworks like EBM and stakeholder engagement offer pathways for success, substantial efforts are required to overcome data gaps, funding limitations, and conflicting policy objectives. Continued innovation and global cooperation are vital to achieving sustainable outcomes for biodiversity and human well-being.

The concept of sustainable use has become a cornerstone in contemporary discussions on environmental conservation and resource management. It integrates ecological, economic, and social dimensions to ensure that natural resources meet current needs without compromising future generations' ability to fulfill theirs. This review synthesizes key scientific research to highlight the evolution, principles, challenges, and applications of sustainable use in diverse contexts.

The term "sustainable use" gained prominence following the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. The resulting Convention on Biological Diversity (CBD) emphasized sustainable use as one of its three main objectives (CBD, 1992). This marked a shift from purely conservationist approaches to strategies that harmonize human activity with ecological integrity. A seminal paper by Robinson (1993) argued that sustainable use involves managing resources to ensure both ecological resilience and socioeconomic benefits. This dual approach differentiates sustainable use from preservationist models, which often advocate for minimal human interaction with ecosystems.

Scientific literature identifies three key principles underpinning sustainable use:

Ecological Integrity: Resources must be used at a rate that does not exceed their natural regenerative capacity. For instance, studies on fisheries management demonstrate that maintaining fish stocks within biologically sustainable limits prevents ecosystem collapse (Hilborn et al., 2020).

Equity: Sustainable use must consider intergenerational and intra-generational equity. This ensures fair resource distribution among current stakeholders and between present and future generations (Padilla & Gibson, 2019).

Adaptive Management: Recognizing the dynamic nature of ecosystems, adaptive management involves continuous monitoring and adjustment of resource use strategies to respond to environmental and social changes (Walters & Holling, 1990).

Despite its theoretical appeal, implementing sustainable use poses significant challenges:

Governance Issues: Effective sustainable use requires robust governance structures. Weak regulatory frameworks often lead to overexploitation and resource depletion. Ostrom's (1990) research on common-pool resources underscores the importance of participatory governance in achieving sustainable outcomes.

Economic Pressures: Short-term economic gains often conflict with long-term sustainability goals. For example, deforestation for agriculture and mining generates immediate revenue but undermines ecosystem services critical for future prosperity (Barlow et al., 2018).

Knowledge Gaps: Insufficient data on resource dynamics and ecological thresholds impedes informed decision-making. This is particularly evident in marine ecosystems, where limited understanding of species interactions complicates sustainable fisheries management (Pauly et al., 2002).

Social and Cultural Barriers: Diverse cultural values and socioeconomic conditions influence resource use practices. Integrating traditional knowledge with scientific approaches can enhance the acceptability and effectiveness of sustainable use

strategies (Berkes, 2009).

Applications of Sustainable Use

The sustainable use concept has been applied across various sectors and scales:

Forestry: The sustainable management of forests balances timber production with biodiversity conservation. Certification schemes like the Forest Stewardship Council (FSC) promote responsible forestry practices that align with sustainable use principles (Putz et al., 2012).

Wildlife Conservation: Sustainable use of wildlife, such as trophy hunting and ecotourism, generates economic incentives for conservation while supporting local livelihoods (Dickman et al., 2019).

Agriculture: Sustainable agricultural practices, including agro ecology and organic farming, reduce environmental impacts and enhance food security. Research by Pretty (2008) highlights the role of sustainable agriculture in mitigating climate change and conserving biodiversity.

Water Resources: Integrated water resource management (IWRM) exemplifies sustainable use by addressing competing demands for water in ways that protect ecosystems and ensure equitable access (GWP, 2000). The concept of sustainable use represents a pragmatic approach to reconciling human development with ecological stewardship. While its implementation faces significant challenges, advancements in governance, technology, and interdisciplinary research offer promising pathways. The integration of traditional knowledge, stakeholder participation, and adaptive management will be crucial in operationalizing sustainable use across diverse contexts. Future research should prioritize filling knowledge gaps and developing scalable models that address the socio-ecological complexities of sustainable resource use.

Conclusion & Discussion

According to the data analyzed using primary data and secondary data under the mixed research methodology, there is less importance in the community regarding sustainable use and policy planning. There is also very little understanding about

development, sustainable development and sustainable development goals. When analyzing the data, it is found that even among those receiving education and higher education, there is a low level of knowledge. Even conservation strategies are implemented without proper understanding. These concepts and studies in the world can be investigated in this way, Biodiversity, a cornerstone of ecological balance and human well-being, is increasingly under threat from habitat loss, climate change, overexploitation, and invasive species. Developing policies that ensure the sustainable use of biodiversity while addressing these challenges is critical. One key policy framework is the ecosystem-based approach, which integrates biodiversity conservation with the sustainable use of resources. This approach prioritizes protecting ecosystems that provide essential services like carbon sequestration, water filtration, and pollination, while promoting responsible resource use by local communities (CBD, 2020). Policies under this framework should balance conservation objectives with socio-economic needs, enhancing both environmental and community resilience. Another important area is mainstreaming biodiversity across sectors, including agriculture, fisheries, and urban development. This involves aligning policies and practices with biodiversity goals, such as adopting agroecological farming methods or sustainable fishing quotas to minimize habitat degradation and species loss (IPBES, 2019). Incentivizing conservation through market-based mechanisms like Payments for Ecosystem Services (PES) and biodiversity offsets can also drive sustainable use. For instance, PES programs financially reward stakeholders for managing land in ways that preserve biodiversity, creating a win-win for conservation and livelihoods (Wunder et al., 2018). Moreover, policies must address emerging challenges such as climate change. Adaptive management strategies, informed by robust scientific research, can guide the integration of climate resilience into biodiversity policies. This includes restoring degraded ecosystems and creating wildlife corridors to facilitate species adaptation to changing conditions (IUCN, 2021). Lastly, fostering international cooperation is vital. Agreements like the Convention on Biological Diversity (CBD) and its Kunming-Montreal Global Biodiversity Framework offer global guidelines for aligning national policies with shared conservation goals. In conclusion, formulating effective biodiversity policies requires a holistic, inclusive, and adaptive approach. Collaboration among governments, researchers,

and communities is essential for ensuring the sustainable use of biodiversity in the face of conservation challenges.

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