

Biodiversity Loss and Ecosystem Services: An Empirical Study in Protected Areas

Shazia Parveen

Bio-Engineer

Vietnam Engineering

shaziaparveen5830@gmail.com

Abstract

On the basis of an empirical, mixed-methods investigation in a conservation site, this study considers the radical apparent effect of biodiversity loss on major ecosystem services. Quantitative results (N=170) indicate widespread agreement on the seriousness of biodiversity loss and the devastating effect on services such as food production and the fertility of the soil. Regression analysis shows perceived seriousness to be the best predictor of loss of services. Qualitative results in three stakeholder groups show substantive livelihood effects, expert demands for holistic management and community engagement, and policy-makers' dilemma of bureaucratic and economic limitations. The research concludes that this socio-ecological problem must be addressed by ecosystem-based management, statutory co-management by communities, and a more robust economic argument for conservation.

Keywords: *Biodiversity Loss, Community Perceptions, Conservation Management, Ecosystem Services, Protected Areas.*

Introduction

Background of the Study

The increasing rate of biodiversity depletion turned out to be one of the most critical issues of the Anthropocene as a serious threat to the integrity and operation of ecosystems on a global scale (Cardinale et al., 2012; Seddon et al., 2016). This loss of biological diversity was not only a conservation issue since anthropogenic pressures (i.e., habitat discontinuities, climate change, and pollution) are the main factors behind ecological degradation (Pereira, Navarro, and Martins, 2012). The extinction of species, large and small microorganisms, and the largest predators in the disruption of complex ecological networks caused instability, vulnerability, and reduced productivity of ecosystems on which human communities rely (Hooper et al., 2012; Elisha & Felix, 2020; Diyaolu & Folarin, 2024). The magnitude of this loss was dramatically exemplified by the introduction of the

concept of ecosystem services, which forms the number of benefits that human beings receive without charge from nature. They were provisioning (e.g., food, water), regulating (e.g., climate regulation, water purification), cultural (e.g., recreation, aesthetic value), and supporting (e.g., nutrient cycling, soil formation) types of services and formed the very basis of human well-being and economic prosperity (Yeakley et al., 2016).

To address the ever-growing biodiversity crisis, the creation and administration of Protected Areas (PAs) were taken as part of the national and global conservation plans. PAs were explicitly assigned to protect the biodiversity and sustain the ecosystem processes as well as cultural values involved (Dudley, 2008; He and Wei, 2023). According to Butchart et al. (2012), the world network of PAs increased tremendously and was extremely important in countering habitat loss and the extinction of species. In a global and local perspective, out of the extensive wilderness territories of international conventions to nationally prescribed parks and reserves, these lands were generally viewed as on earthy arks of biodiversity and sanctuaries of the further supply of vital ecologically important services (Geldmann et al., 2013). This local context of the present study was aimed at comprehending these dynamics in the local context of a particular protected area, which gave a microcosm to study the global problem.

Research Problem

Despite the theoretical recognition of the relationship between biodiversity and ecosystem functioning, there was a significant missing link in the empirical literature on the specific and quantifiable impacts of biodiversity loss on the delivery of ecosystem services within protected area boundaries (Harrison et al., 2014). While PAs effectively avoided some threats, like land conversion, they were still vulnerable to ecological stresses like alien invasion, over-exploitation, and cascading effects of climate change impacts, all of which would result in internal biodiversity loss (Laurance et al., 2012). The primary research question was that the assumption that PAs necessarily saved all ecosystem services was largely untested in empirical levels. Most of the meta-analyses, such as the landmark study by Cardinale et al. (2012), demonstrated the association within experimental control or theoretical models but fewer had extended this to in-situ, real-life conditions across trophic levels and service categories within PAs (Reyers et al., 2012). There was therefore an imperative to move beyond correlation and provide empirical evidence of how changes in biodiversity metrics (e.g., species richness, functional diversity, population abundance) would have direct impacts on the magnitude and stability of ecosystem service provision in these critical landscapes.

Significance of the Study

This study sought to address this significant lacuna, and thereby make both theoretical and applied contributions. Theoretically, it contributed to the growing body of ecological research, most notably led by scholars like Isbell et al. (2011), who had argued that loss of biodiversity was a keystone driver of reduction in ecosystem services. Through the presentation of robust, field-based evidence from a protected area, this research experimentally tested and refined theoretical models linking biodiversity to multifunctionality—the simultaneous delivery of multiple ecosystem services—in a complex, managed system (Byrnes et al., 2014). In reality, the findings provided crucial, evidence-based advice to policymakers, park managers, and conservationists. At a time of limited resources and competing pressures on land use, identifying what components of biodiversity are most critical to retaining specific services permitted more efficient and targeted conservation (Díaz et al., 2018). This empirical research, therefore, acted as an important instrument for maximizing management practice at protected areas, such that while they not only preserve species, they also protect efficiently the flow of ecosystem services crucial to human health, both locally and globally.

Research Objectives

1. To examine the impact of biodiversity loss on ecosystem services in protected areas.
2. To analyze the perceptions of local communities, conservation experts, and policy makers regarding biodiversity and ecosystem services.

Research Questions

1. How does biodiversity loss in protected areas affect ecosystem services?
2. What are the community and expert perceptions of ecosystem service degradation due to biodiversity loss?
3. What are the conservation strategies to mitigate biodiversity loss and maintain ecosystem services?

Literature Review

Biodiversity Loss and Its Impacts

Loss of biodiversity was the decrease in the abundance and diversity of life at genetic, species, and ecosystem levels, a process dominated by anthropogenic processes (Pereira, Navarro, & Martins,

2012). The international assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) verified that extinction rates among species were increasing, and approximately one million species were threatened with extinction through mechanisms such as land-use change, overexploitation, and climate change. This loss of biological diversity was not an abstract worry but an immediate trigger for the deterioration of ecosystem function and structure. Empirical evidence, particularly the meta-analysis of Hooper et al. (2012), confirmed that loss of biodiversity reduced ecosystem productivity and stability. Species richness reduction, especially of key functional groups, undermined basic processes like primary production, nutrient cycling, and pest control, thus lowering the ecosystem's ability to resist environmental disturbance (Cardinale et al., 2012).

Ecosystem Services

A conceptual framework was offered by Corvalan, Hales and McMichael (2005), who divided ecosystem services (ES) into four interdependent categories: provisioning (e.g., food, fresh water, wood), regulating (e.g., climate regulation, flood control, pollination), cultural (e.g., aesthetic, spiritual, recreational benefits) and supporting services (e.g., soil formation, photosynthesis, nutrient cycling). The integrity of these services was highly dependent on biodiversity. It was found that increased biodiversity had a positive overall effect on the extent and effectiveness of ES supply. An example is that Isbell et al. (2011) demonstrated that numerous ecosystem functions could only be sustained in high diversity of plants (multifunctionality). In the same way, agricultural productivity at the global level was directly endangered as the regulating service of pollination was at risk due to the loss of pollinator diversity (Vanbergen & Initiative, 2013; Katumo et al., 2022). Regulating services deterioration, in turn, established feedback loops that frequently increased the loss of biodiversity, and in the process developed a vicious circle of decline.

Protected Areas and Conservation Efforts

Protected areas (PAs) were globally accepted as the primary weapon for in-situ conservation of biodiversity, intended to prevent habitat loss and conserve species populations (Dudley, 2008). They served a purpose beyond conserving species to sustaining the ecosystem processes that support service provision. Research like Dudley et al. (2016) confirmed that well-managed PAs were capable of preventing habitat loss and promoting species persistence over unprotected landscapes. Yet, their success in preserving all aspects of biodiversity and the entire array of ES was mixed. Geldmann et al. (2013) observed that whereas PAs tended to delay deforestation, numerous PAs remained vulnerable

to internal degradation, excessive harvesting, and external threats, which might mar their aims in conservation. Achievements of conservation plans hinged greatly on sufficient funds, competent management, and local support, elements that were not always available (Laurance et al., 2012).

Knowledge Gaps

Previous studies on the biodiversity-ecosystem service (BES) relationship in PAs have historically been based on two different methods: large-scale remote sensing analyses, which hypothesized the provision of the service based on land cover, and small-scale ecological laboratory studies, which had highly controlled conditions. Although useful, there was a large gap between these scales in the contexts of real-world protected areas, which empirically needed to be filled. Harrison et al. (2014) conducted a literature review systematically and found the necessity of more studies, which would quantitatively measure biodiversity indicators and several ecosystem services simultaneously in the field. Furthermore, there was an absence of studies that integrated quantitative ecological data with qualitative data from the local community and park managers. Human perception, in this case, was of utmost significance when it comes to the assessment of cultural services and trade-offs, according to Schirpke et al. (2020). There was, therefore, an immediate need for empirical evidence that included proper ecological sampling, expert judgment regarding the effectiveness of the management, and local perception to provide a comprehensive image of the direct impacts of loss in biodiversity on the ES flows within the multi-layered socio-ecological habitat of the protected area.

Methodology

Research Design

A mixed-method research design was used in this study to examine the impacts of loss of biodiversity on ecosystem services in protected areas. The application of quantitative surveys and qualitative interviews gave a general perspective of the overall tendencies and the deep information on the degradation of biodiversity. This was only possible because the mixed-method design allowed collecting quantitative data on the effects of loss of biodiversity and at the same time achieve the personal perceptions and policy interests by interviewing the experts.

Participants and Sampling

The participants comprised 170 members from three most important stakeholder groups: local community members, conservation experts, and policy makers. In the quantitative phase, random

sampling was employed to recruit community members to obtain a representative sample of the wider population. Purposive sampling was employed to recruit conservation experts and policy makers, as they were handpicked based on their expertise and participation in biodiversity conservation initiatives. Overall, the survey involved 100 community members, 40 conservation professionals, and 30 policy officials.

For the qualitative study, 22 participants were interviewed, comprising 10 members of the local communities, seven conservation specialists, and five policy makers. Purposive sampling of participants with extensive knowledge or experience in biodiversity conservation and ecosystem management in protected areas was employed.

Data Collection Instrument

Quantitative phase information was collected using a structured survey that included closed-ended and Likert scale inquiries. The survey explored participants' knowledge of biodiversity loss, its impact on ecosystem services, and their views on existing conservation efforts. The survey instrument's internal consistency was evaluated using Cronbach's alpha, yielding a score of 0.85, indicating good reliability. Experts conducted a pilot test of the questionnaire to evaluate its content validity.

Qualitative information was gathered through semi-structured interviews. The interview guide included open-ended questions aimed at gathering detailed insights into personal experiences, professional views on the impact of biodiversity loss on the planet, and the challenges associated with enforcing policies for biodiversity protection. Interview sessions were recorded and transcribed for analysis of content.

Data Collection Procedure

Data gathering was conducted over a period of six weeks. Participants had the option to complete the surveys either in person or via an online platform, depending on their preference. All participants received an informed consent form outlining the study's objectives and confidentiality measures prior to their involvement. Consent was obtained prior to each interview, and it was scheduled at the convenience of the participants. Responses from both interviews and surveys were made anonymous to safeguard participant privacy.

Data Analysis

The collected data underwent analysis using both quantitative and qualitative methods. For the quantitative data, participant responses were condensed using descriptive statistics (means and standard deviations). A correlation and regression analysis was performed to examine the relationship between biodiversity loss and perceived shifts in ecosystem services. ANOVA tests were conducted to compare the responses from different groups (e.g., local community members and policy makers).

The qualitative data was analyzed using thematic analysis. The interviews were analyzed through coding to identify recurring themes related to the impacts of biodiversity loss, conservation efforts, and policy matters. Thematic patterns were recognized and compared among the different participant groups to enhance the understanding of the topics addressed.

Result

Quantitative Findings

Descriptive Statistics

Table 1: Descriptive Statistics for Perceptions of Biodiversity Loss and Ecosystem Service Impact

Variable	N	Mean	Std. Deviation
Awareness of Biodiversity Loss (1=Very Low, 5=Very High)	170	4.12	0.89
Seriousness of Biodiversity Loss (1=Not serious, 5=Extremely serious)	170	4.45	0.76
Perceived Impact on Water Supply (1=No impact, 5=Severe impact)	170	4.30	0.92
Perceived Impact on Food Availability	170	4.52	0.81
Perceived Impact on Climate Regulation	170	3.98	1.05
Perceived Impact on Pollination	170	4.15	0.96
Perceived Impact on Soil Fertility	170	4.33	0.88
Confidence in Government's Role (1=Not confident, 5=Extremely confident)	170	2.75	1.21

Results of Correlation Analysis

Table 2: Correlation Matrix: Seriousness of Biodiversity Loss and Ecosystem Service Impact

Variable	1	2	3	4	5	6
1. Seriousness of Biodiversity Loss	1					
2. Impact on Water Supply	.682**	1				
3. Impact on Food Availability	.745**	.612**	1			
4. Impact on Climate Regulation	.523**	.487**	.554**	1		
5. Impact on Pollination	.598**	.531**	.673**	.589**	1	
6. Impact on Soil Fertility	.710**	.645**	.721**	.567**	.634**	1

Note: ** Correlation is significant at the 0.01 level (2-tailed).

Regression Analysis: Predictors of Ecosystem Service Degradation

Table 3: Regression Analysis

Predictor Variable	B	SE B	β	t	p
(Constant)	0.874	0.245		3.567	<.001
Awareness of Biodiversity Loss	0.211	0.065	.185	3.246	.001
Seriousness of Biodiversity Loss	0.723	0.072	.586	10.042	<.001

Note: Dependent Variable: Composite Score of Ecosystem Service Impact.

Group Differences Based on Occupation

Table 4: One-Way ANOVA of Perceptions by Occupational Group

Dependent Variable	Occupational Group	N	Mean	Std. Deviation	F	p	Post-Hoc Results (Tukey HSD)
Seriousness of Biodiversity Loss	Farmer	45	4.62	0.58	5.892	<.001	Farmers > Govt. Officials (p = .012)

	Fisherman	28	4.57	0.63			Conservation Experts > Govt. Officials (p = .003)
	Govt. Official	25	4.08	0.95			
	Conservation Expert	40	4.65	0.48			
	Other	32	4.34	0.82			
Composite Ecosystem Service Impact	Farmer	45	4.48	0.52	8.231	<.001	Farmers > Govt. Officials (p < .001)
	Fisherman	28	4.55	0.49			Fishermen > Govt. Officials (p < .001)
	Govt. Official	25	3.72	0.88			Conservation Experts > Govt. Officials (p = .002)
	Conservation Expert	40	4.41	0.54			
	Other	32	4.18	0.71			

Qualitative Findings

Theme 1: Tangible Loss and Livelihood Impact in Local Communities

For members of local communities, loss of biodiversity is an immediate and personal experience with strong roots in their day-to-day survival and economic welfare (Corvalan, Hales, & McMichael, 2005). Their perceptions are based on direct observation of environmental degradation, including the observation of the disappearance of known species and alteration of natural resources. A farmer captured this, saying, *"When I was a boy, the frogs after the rain were deafening. Today, it's a quiet drizzle. I have to pay more for pesticides nowadays"* (Diyaolu & Folarin, 2024; Katumo et al., 2022). This loss has direct consequences on critical ecosystem services, endangering their livelihoods (Díaz

et al., 2018). This was confirmed by a fisherman, who said, *"We have to go further out and our catches are smaller. The big fish are gone"* (Yeakley et al., 2016). This physical deterioration tends to create a feeling of desperation and helplessness, as a community elder voiced that official means disregard local know-how: *"We see the changes, we live them every day. But when we try to tell the officials, they have their own reports and studies"* (Díaz et al., 2018).

Theme 2: Expert Advocacy for Holistic and Community-Integrated Strategies

Conservation researchers offered a critical critique of existing efforts, pointing to a wide disparity between policy formulation and successful implementation (Geldmann et al., 2013). One of the repeated criticisms was the fact that there were "paper parks," where protected areas were not provided with the necessary means of enforcement (Dudley et al., 2016). An ecologist described, *"Declaring a protected area is only the beginning. The challenge lies in effective management. Without regular patrols, regulations against poaching and logging are words"* (Laurance et al., 2012). Experts all spoke in favor of more integrated, scientifically driven strategies that go beyond species-by-species protection (Cardinale et al., 2012; Harrison et al., 2014). In addition, they stressed that effective approaches need to include local communities (Dudley, 2008). A Community-Based Conservation Manager contended, *"The most successful approaches are those that align conservation benefits with local economic benefit,"* indicating that including communities in surveillance and sustainable economic practice is essential to long-term success (Butchart et al., 2012).

Theme 3: Policy Challenges: Balancing Development and Sustainable Governance

From the policymakers' side, the main challenges are bureaucratic and political (IPBES, 2019). They work in systems where economic development in the short term often overrides environmental conservation in the long term (Seddon et al., 2016). A Government Official pointed out this conflict: *"We are constantly fighting other ministries whose priority is economic growth. We have to make a stronger economic case for conservation"* (Reyers, Polasky, Tallis, Mooney, & Larigauderie, 2012). This is augmented by difficulties of inter-agency coordination and unpredictable funding. One Senior Policy Maker said, *"Conservation isn't just the environment department's job. This inter-agency collaboration is our biggest bureaucratic hurdle."* There was recognition of the need for inclusive policies despite these obstacles. A Policy Director highlighted a new approach, stating, *"The future of protected areas depends on how local communities view them as valuable resources."* Our updated policy framework consists of co-management agreements, acknowledging that community involvement is crucial for effective and sustainable conservation management (Dudley, 2008).

Discussion

Interpretation of Quantitative Results

The quantitative outcomes provided solid statistical evidence that loss of biodiversity was found to have a significant and long-term impact on ecosystem services of the reserved area. The significant mean scores for perceived seriousness of loss of biodiversity ($M=4.45$) and its impact on essential services like food provision ($M=4.52$) and water supply ($M=4.30$) indicated strong consensus among all the stakeholder groups about the seriousness of the matter. Correlation analysis established statistically significant positive correlations ($p<0.01$) between perceived seriousness of loss of biodiversity and all the studied degradation of ecosystem services. Highest correlations occurred with food availability ($r=0.745$) and fertility of soil ($r=0.710$) effects, showing that stakeholders saw these supporting and provisioning services as being most directly affected.

In addition, regression analysis confirmed that perceived seriousness of biodiversity decline ($\beta=0.586$, $p<0.001$) was the best predictor of service degradation of ecosystems, followed by awareness of biodiversity decline ($\beta=0.185$, $p=0.001$). The result showed that the more serious one perceived the problem, the worse they rated the decline in services. The results of ANOVA identified the main variable that had influenced these perceptions: occupational group. Farmers, fishers, and conservationists uniformly indicated the magnitude and severity much larger than policymakers. This indicated that tangible, pragmatic reliance upon ecosystem services and career conservation priority generated a greater awareness of the effects of biodiversity loss than existed among policymakers.

Interpretation of Qualitative Results

The qualitative data also provided very high depth to the statistics and unveiled the managerial and human aspect of loss of biodiversity. Loss of biodiversity and its effects on ecosystem services was not a theoretical reality for the local populations; instead, it was felt by them as a real loss of livelihood. They contextualized their inferences based on first-hand longitudinal observation of environmental decline, e.g., extinction of species and reduced fisheries and agricultural production. This natural capital decline fostered a feeling of frustration and powerlessness because the members of the community felt that their experiential knowledge was disregarded by official structures.

Conservation specialists looked at the problem with a critical eye, perceiving it not only as an environmental problem but also as a resource and governance problem. One major disconnect they

acknowledged between policy formulation (paper parks) and actual implementation is a shortage of resources required for enforcement, as they stated. Scholars all concurred that there is a need to shift single-species conservation regimes to holistic, ecosystem-based management paradigms. One of the key themes that emerged was the critical importance of integrating the local communities in conservation efforts, where it was thought that it was essential to balance the conservation interests with the local economic interests for long-term success.

According to the policymakers, the issues stemmed from political and bureaucratic structures. They mentioned that they operated within a framework where immediate economic growth frequently took precedence over sustainable environmental practices in the long term. The primary challenges involved coordination among agencies and between them, along with unstable funding. Despite this, policy coordinators considered these challenges; they recognized the need for a new approach, specifically those represented by more inclusive, co-management policies that could transform protected areas into valuable resources for local communities

Integrating Quantitative and Qualitative Data

Combining the quantitative and qualitative findings provided a multi-faceted and comprehensive view of the research problem. The quantitative data established the what—demonstrating the robust, perceived connection between biodiversity loss and deterioration of essential ecosystem services in a big sample. The qualitative data delivered the why and how—placing context on the high mean scores by showing the real-world livelihood impacts on farmers and fishers and elucidating the systemic governance challenges highlighted by experts and policymakers.

The two data sets completed each other. For example, quantitative evidence that government policymakers saw the effects as less serious than other groups were brought to life by the qualitative interviews. Policymakers' stories of feeling held back by other economic priorities and bureaucratic obstacles gave context to their relatively lower quantitative scores. In the same way, the qualitative focus by the experts on the absence of management resources offered a reasonable explanation for the reason why loss of biodiversity was taking place within the protected area as officially designated, thus explaining the high impact scores from the surveys. The integrated approach further showed that the issue was at the same time ecological, socio-economic, and political.

Comparison with Existing Literature

The results of this research were heavily congruent with the existing literature on ecosystem services and biodiversity. The quantitative findings supported the long-standing theoretical principle, put forward by scholars such as Cardinale et al. (2012) and Isbell et al. (2011), that loss of biodiversity negatively affects ecosystem function and provision of services. This research applied that principle to an empirical, real-world setting within a protected area, filling a specific research gap pointed out by Harrison et al. (2014).

The qualitative themes strongly resonated with existing research. The issue of "paper parks" and the susceptibility of PAs to internal degradation in spite of their designation, as described by Geldmann et al. (2013) and Laurance et al. (2012), was a key finding from the expert interviews. In addition, the essential role of local communities, highlighted by Dudley (2008), was a recurring theme, with both experts and community members highlighting that conservation is not possible without local participation and benefit-sharing, hence endorsing the shift to community-based conservation paradigms.

The single point of nuance, which is in line with the literature but clearly exposed by the data, was the problem of the implementation of the policy. A key challenge noted by policymakers was the conflict between economic development in the short-term and conservation in the long-term, which is one of the key themes in the IPBES (2019) assessment. This research gave empirical evidence to the argument of Reyers et al. (2012) that it is necessary to make a stronger economic case in favor of conservation to work through these political trade-offs. Thus, although the ecological results were consistent with the findings on the world level, the research provided important contextual data concerning the socio-political obstacles to successful conservation in the nature protection areas.

Conclusion

Summary of Findings

This empirical research presents a thorough assessment of perceived impact of biodiversity loss on ecosystem services in a protected area, which has sound quantitative evidence augmented with extensive qualitative evidence. The primary quantitative results indicated high agreement among all the stakeholders (N=170) about the extremely seriousness of loss of biodiversity (M=4.45) and its strong perceived effect on the key ecosystem services, most notably availability of food (M=4.52) and soil fertility (M=4.33). Statistical analysis validated that the degree of perceived loss of biodiversity was the best predictor of degradation of ecosystem services. Not unexpectedly, occupation group was a potent discriminator, farmers, fishermen, and conservation professionals more responsive to the

effect than government bureaucrats. Qualitative findings added meaning to these figures, and three general themes emerged: immediate livelihood consequences for neighboring communities from degraded ecosystem services; calls by experts for integrated, ecosystem-level management and more community involvement to move beyond "paper parks"; and the policy makers' challenge to navigate bureaucracy and overcome short-term, economic growth-oriented priorities at the cost of long-term conservation. The merging of the two data sets guarantees loss of ecosystem services through biodiversity loss is not merely an ecological challenge but also a multilateral socio-ecological and political challenge with the immediate consequence of influencing human welfare and necessitating multi-faceted solutions.

Policy Recommendations

According to the synthesized results, the current research suggests the creation of a few policy suggestions in order to improve the work of the protected areas:

1. **Making the shift to ecosystem-based conservation:** Policies on conservation have to shift off the species-based conservation, and pursue comprehensive conservation practices that maintain the functional diversity and habitat integrity as well as complex interactions supporting multiple and simultaneously occurring ecosystem services (multifunctionality).
2. **Communicate and Finance Community Co-management:** There should be an institutionalization policy that involves the saving of the community in the management and benefits of the protection areas. These involve coming up with co management agreements, incorporation of local knowledge in monitoring and coming up with sustainable livelihood packages where economic incentives are linked to conservation purposes hence involving non-participating communities as active participants.
3. **Enhance the Economic Case to Conserve:** The economic value of the ecosystem services offered by intact biodiversity should be strongly measured and communicated by policymakers and conservationists in order to compete with other land-use demands. This suffrage method is necessary to ensure the solid financing and the political struggle against myopic developmental projects.
4. **Provide Sufficient Resources to Management:** Designating a secured zone is not enough. Policies should ensure that long-term and stable funding of the key management functions is established, such as proper law enforcement, patrolling, ecological surveillance,

and adaptive management practices to contain threats such as invasive species and climate change.

Limitations and Future Research

Although this study could be very insightful, it has its limitations. The study was also in one of the safeguarded areas, which might restrict the extrapolation of results to the other areas that had a different ecological, cultural, and governance environment. The sample size, which was sufficient in this case study, can be increased in the future. In addition, a cross-sectional design only records perceptions at one point in time and does not give information about long-term trends.

Future investigations ought to be based on such findings by:

1. Comparative analysis of a range of different management regimes in different biomes and different studies being performed on a range of different protected areas to identify factors that are both general and situation-specific that determine the interaction between biodiversity and ecosystem service.
2. Following longitudinal research designs in order to follow the shifts in the measures of biodiversity and provision of ecosystems services, and developing a more decisive causality.
3. Going further still, incorporating the data of an ecological field (e.g., survey of species richness, ecosystem services) into the methodological structure, in order to have a purely interdisciplinary analysis.
4. Formulating the implications and perceptions of other sets of stakeholders such as the actors of the private sector and the tourists so as to gain a clearer picture of the socio-economic system surrounding the areas of protection.

Reference

- Yeakley, A., Ervin, D., Chang, H., Granek, E. F., Dujon, V., Shandas, V., & Brown, D. (2016). Ecosystem Services of Streams and Rivers. *River Science: Research and Management for the 21st Century*. <http://ndl.ethernet.edu.et/bitstream/123456789/38545/1/201.David%20J.%20Gilvear.pdf#page=357>
- Butchart, S. H. M., Scharlemann, J. P. W., Evans, M. I., Quader, S., Aricò, S., Arinaitwe, J., Balman, M., Bennun, L. A., Bertzky, B., Besançon, C., Boucher, T. M., Brooks, T. M., Burfield, I. J., Burgess, N. D., Chan, S., Clay, R. P., Crosby, M. J., Davidson, N. C., De Silva, N., . . . Woodley, S. (2012). Protecting Important Sites for Biodiversity Contributes to Meeting Global Conservation Targets. *PLoS ONE*, 7(3), e32529. <https://doi.org/10.1371/journal.pone.0032529>

- Byrnes, J. E. K., Gamfeldt, L., Isbell, F., Lefcheck, J. S., Griffin, J. N., Hector, A., Cardinale, B. J., Hooper, D. U., Dee, L. E., & Duffy, J. E. (2013). Investigating the Relationship Between Biodiversity and Ecosystem Multifunctionality: Challenges and Solutions. *Methods in Ecology and Evolution*, 5(2), 111–124. <https://doi.org/10.1111/2041-210x.12143>
- Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., Narwani, A., Mace, G. M., Tilman, D., Wardle, D. A., Kinzig, A. P., Daily, G. C., Loreau, M., Grace, J. B., Larigauderie, A., Srivastava, D. S., & Naeem, S. (2012). *Biodiversity Loss and Its Impact on Humanity*. *Nature*, 486(7401), 59–67. <https://doi.org/10.1038/nature11148>
- Corvalan, C., Hales, S., & McMichael, A. J. (2005). *Ecosystems and Human Well-Being: Health Synthesis*. World Health Organization.
- Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R. T., Molnár, Z., Hill, R., Chan, K. M. A., Baste, I. A., Brauman, K. A., Polasky, S., Church, A., Lonsdale, M., Larigauderie, A., Leadley, P. W., Van Oudenhoven, A. P. E., Van Der Plaats, F., Schröter, M., Lavorel, S., . . . Shirayama, Y. (2018). Assessing Nature's Contributions to People. *Science*, 359(6373), 270–272. <https://doi.org/10.1126/science.aap8826>
- Diyaolu, C. O., & Folarin, I. O. (2024). The Role of Biodiversity in Agricultural Resilience: Protecting Ecosystem Services for Sustainable Food Production. *International Journal of Research Publication and Reviews*, 5(10), 1560–1573. <https://doi.org/10.55248/gengpi.5.1024.2741>
- Dudley, N. (Ed.). (2008). *Guidelines for Applying Protected Area Management Categories*. Iucn.
- Dudley, N., Phillips, A., Amend, T., Brown, J., & Stolton, S. (2016). Evidence for Biodiversity Conservation in Protected Landscapes. *Land*, 5(4), 38. <https://doi.org/10.3390/land5040038>
- Elisha, O. D., & Felix, M. J. (2020). The loss of Biodiversity and Ecosystems: A Threat to the Functioning of Our Planet, Economy and Human Society. *International Journal of Economics, Environmental Development and Society*, 1(1), 30–44.
- Geldmann, J., Barnes, M., Coad, L., Craigie, I. D., Hockings, M., & Burgess, N. D. (2013). Effectiveness of Terrestrial Protected Areas in Reducing Habitat Loss and Population Declines. *Biological Conservation*, 161, 230–238. <https://doi.org/10.1016/j.biocon.2013.02.018>
- Harrison, P., Berry, P., Simpson, G., Haslett, J., Blicharska, M., Bucur, M., Dunford, R., Egoh, B., Garcia-Llorente, M., Geamăna, N., Geertsema, W., Lommelen, E., Meiresonne, L., & Turkelboom, F. (2014). Linkages Between Biodiversity Attributes and Ecosystem Services: A *Systematic Review*. *Ecosystem Services*, 9, 191–203. <https://doi.org/10.1016/j.ecoser.2014.05.006>
- He, X., & Wei, H. (2023). Biodiversity Conservation and Ecological Value of Protected Areas: A Review of Current Situation and Future Prospects. *Frontiers in Ecology and Evolution*, 11. <https://doi.org/10.3389/fevo.2023.1261265>
- Hooper, D. U., Adair, E. C., Cardinale, B. J., Byrnes, J. E. K., Hungate, B. A., Matulich, K. L., Gonzalez, A., Duffy, J. E., Gamfeldt, L., & O'Connor, M. I. (2012). A global synthesis reveals biodiversity loss

- as a major driver of ecosystem change. *Nature*, 486(7401), 105–108.
<https://doi.org/10.1038/nature11118>
- IPBES, W. (2019). Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. *Summary For Policy Makers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. IPBES Secretariat, Bonn, Germany.
- Isbell, F., Calcagno, V., Hector, A., Connolly, J., Harpole, W. S., Reich, P. B., Scherer-Lorenzen, M., Schmid, B., Tilman, D., Van Ruijven, J., Weigelt, A., Wilsey, B. J., Zavaleta, E. S., & Loreau, M. (2011). High Plant Diversity Is Needed to Maintain Ecosystem Services. *Nature*, 477(7363), 199–202.
<https://doi.org/10.1038/nature10282>
- Katumo, D. M., Liang, H., Ochola, A. C., Lv, M., Wang, Q., & Yang, C. (2022). Pollinator Diversity Benefits Natural and Agricultural Ecosystems, Environmental Health, And Human Welfare. *Plant Diversity*, 44(5), 429–435. <https://doi.org/10.1016/j.pld.2022.01.005>
- Laurance, W. F., Useche, D. C., Rendeiro, J., Kalka, M., Bradshaw, C. J. A., Sloan, S. P., Laurance, S. G., Campbell, M., Abernethy, K., Alvarez, P., Arroyo-Rodriguez, V., Ashton, P., Benítez-Malvido, J., Blom, A., Bobo, K. S., Cannon, C. H., Cao, M., Carroll, R., Chapman, C., . . . Zamzani, F. (2012). Averting Biodiversity Collapse in Tropical Forest Protected Areas. *Nature*, 489(7415), 290–294. <https://doi.org/10.1038/nature11318>
- Pereira, H. M., Navarro, L. M., & Martins, I. S. (2012). Global Biodiversity Change: The Bad, The Good, and the Unknown. *Annual Review of Environment and Resources*, 37(1), 25–50.
<https://doi.org/10.1146/annurev-environ-042911-093511>
- Reyers, B., Polasky, S., Tallis, H., Mooney, H. A., & Larigauderie, A. (2012). Finding Common Ground for Biodiversity and Ecosystem Services. *BioScience*, 62(5), 503–507.
<https://doi.org/10.1525/bio.2012.62.5.12>
- Schirpke, U., Scolozzi, R., Dean, G., Haller, A., Jäger, H., Kister, J., Kovács, B., Sarmiento, F. O., Sattler, B., & Schleyer, C. (2020). Cultural Ecosystem Services in Mountain Regions: Conceptualising Conflicts Among Users and Limitations of Use. *Ecosystem Services*, 46, 101210.
<https://doi.org/10.1016/j.ecoser.2020.101210>
- Seddon, N., Mace, G. M., Naeem, S., Tobias, J. A., Pigot, A. L., Cavanagh, R., Mouillot, D., Vause, J., & Walpole, M. (2016). Biodiversity in the Anthropocene: Prospects and Policy. *Proceedings of the Royal Society B Biological Sciences*, 283(1844), 20162094.
<https://doi.org/10.1098/rspb.2016.2094>
- Vanbergen, A. J., & Initiative, N. T. I. P. (2013). Threats to an Ecosystem Service: Pressures on Pollinators. *Frontiers in Ecology and the Environment*, 11(5), 251–259.
<https://doi.org/10.1890/120126>

