

Influential Social and Economic Determinants of Land Biodiversity Quality: Unveiling the Role of Education, Innovation, and Institutional Factors

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ABSTRACT

Background: Biodiversity conservation is a critical global priority due to its fundamental role in sustaining ecosystem health, resilience, and human well-being. Human activities and factors significantly influence biodiversity dynamics, presenting challenges and opportunities for conservation efforts. Understanding the interplay between human factors and their impacts on the species habitat and species protection index is essential for formulating effective conservation strategies.

Objective: This study aims to investigate the effects of various social and economic factors on biodiversity conservation, including cost of living, climate change adaptation, innovation, quality of education, economic activity, and institutional quality.

Methods: This study has used the Panel FGLS method on 117 countries to estimate the effect of social and economic factors on de facto and de jure biodiversity quality.

Results: The results showed that the selected variables significantly affect the biodiversity quality within which the effects of innovation and institutional quality are surprisingly different from the sustainable practices hypothesis.

Conclusion: Biodiversity conservation is a multifaceted challenge influenced by various human factors. The study findings underscore the significance of education, climate change adaptation, and responsible innovation in enhancing species habitat and its protection. Moreover, a balanced approach to economic activity and thoughtful institutional management is crucial to achieving successful biodiversity conservation outcomes.



Introduction

The Earth's biodiversity is critical to our planet's overall health and sustainability, providing ecosystem services essential for human well-being (CBD, 2014). However, the quality of biodiversity on land is increasingly threatened by numerous socioeconomic factors (Sala et al., 2000; MEA, 2005). Understanding the determinants that influence biodiversity quality is crucial for developing effective conservation strategies and ensuring the long-term survival of ecosystems (Daily, 2000; Nelson et al., 2009). This research paper explores the socioeconomic factors that influence the quality of biodiversity on land and their implications for conservation efforts.

Biodiversity encompasses the variety of species, genetic diversity, and ecosystems present in a particular region. It is fundamental in maintaining ecosystem stability, supporting food production, regulating climate, and providing resources for various industries (Díaz et al., 2006; Cardinale et al., 2012). Biodiversity quality refers to the health, abundance, and resilience of ecosystems, indicating their ability to sustain ecological processes and support a wide range of species (Perrings et al., 2011). A decline in biodiversity quality can have severe consequences for human societies, including reduced food security, increased vulnerability to natural disasters, and a loss of cultural and aesthetic values (MEA, 2005).

Residential, agriculture and infrastructural encroachment of humans is a significant cause of habitat biodiversity change (Cardinale et al., 2012; Duraiappah et al., 2005), and determining human anthropogenic impacts is a crucial for biodiversity preservation. It is a burning issue that the business-as-usual scenarios of climate change are projecting biodiversity depreciation (Visconti et al., 2016; Rondinini & Visconti, 2015). Under such a scenario, 440 mammalian carnivores and ungulate species will decline in abundance by 18–35%, with increased extinction risk by 8–23% by 2050 (Visconti et al., 2016), and 27 European mammal species would lose 25% of their habitat area by 2050 (Rondinini & Visconti, 2015). Worldwide projections of deforestation suggest a substantial extinction risk increase in forest-associated vertebrates (Betts et al., 2017). Species and locations identification of most habitat deformation exposure is vital for prioritizing biodiversity threats management. However, the assessment of sensitive species are taxonomically or geographically restricted, humans are conveniently focused on large-bodied or temperate species. Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES) are assessing and setting the international policy for preventing extinctions goals, which calls for a more comprehensive evaluation accompanied by infrastructure and workflows that enable continuous data based assessment scenarios.

The quality of biodiversity on land is intricately linked to socioeconomic factors that influence land use patterns, resource management practices, and human behaviour (Liu et al., 2007; Fisher et al., 2012). Socioeconomic determinants can vary across different regions, including population growth, urbanization, agricultural intensification, industrial development, and income inequality (Ehrlich & Ehrlich, 1992; Lambin & Meyfroidt, 2011). These factors can directly or indirectly impact biodiversity quality through habitat loss, fragmentation, pollution, overexploitation of natural resources, and introduction of invasive species (Foley et al., 2005; Laurance et al., 2014).

Understanding the socioeconomic determinants of biodiversity quality is crucial for designing effective conservation strategies. Conservation initiatives must consider the social and economic contexts within which they operate to ensure their long-term success (Adams et al., 2004; Oldekop et al., 2016). By addressing the underlying socioeconomic drivers of biodiversity loss, conservation efforts can be better tailored to local needs, engage communities, and promote sustainable land management practices (Andersson & Gaston, 2013; Zafra-Calvo et al., 2020).

Furthermore, recognizing the economic value of biodiversity and its ecosystem services can help integrate conservation into broader development plans and policy frameworks (Ten Brink 2012).

While numerous studies have explored the relationship between socioeconomic factors and biodiversity (Hand et al., 2016; Bjelle et al., 2021), there is a need for further research to enhance our understanding of the complex interactions and causal pathways involved. Moreover, the quality of biodiversity, which extends beyond mere species counts to encompass functional diversity, genetic diversity, and ecosystem services, needs to be considered comprehensively.

This research paper aims to investigate the socioeconomic determinants that influence the quality of biodiversity on land. By examining empirical evidence from various regions and ecosystems, this study seeks to identify key socioeconomic factors that shape biodiversity outcomes and assess their relative importance. Additionally, it aims to understand how these determinants impact biodiversity quality, highlighting the pathways and feedback loops involved. This research paper aims to achieve the following objectives:

- a) Investigate the socioeconomic determinants that influence the quality of biodiversity on land.
- b) Analyze the direct and indirect pathways through which socioeconomic factors impact biodiversity quality.
- c) Identify potential policy recommendations and management strategies for enhancing biodiversity quality in different socioeconomic contexts.

The findings of this research will provide valuable insights for policymakers, conservation practitioners, and land managers, aiding in the development of effective strategies for biodiversity conservation and sustainable land management. Addressing the socioeconomic drivers that underlie biodiversity quality makes it possible to identify opportunities for integrating conservation goals with socioeconomic development objectives, ultimately promoting a more harmonious relationship between human societies and the natural world.

Theoretical and Empirical Review

Determining biodiversity is significantly influenced by the cost of sustenance, as individuals have a tendency to procure the readily available resources in order to maintain their standard of living. The intricate association between human activities, cost of living, and biodiversity has been supported by numerous theoretical reasons as substantiated by research and literature. With the escalation of cost of living, there is an augmented stress on natural resources to cater to the demands of human consumption. This typically results in the extraction of resources, such as logging, mining, and agricultural expansion, leading to the destruction of habitats for numerous plant and animal species. The loss of habitat constitutes one of the primary drivers of biodiversity deterioration. As habitats diminish or vanish, many species are constricted to smaller areas, rendering them more susceptible to extinction (Laurance, Sayer & Cassman, 2014). In areas characterized by high cost of living, there is an elevated demand for wild meat, exotic pets, and other wildlife products. This overexploitation can lead to the depletion of certain species and disrupt the ecological equilibrium. Unsustainable hunting or fishing practices can result in species extinction and reduce overall biodiversity (Ripple et al., 2016). The high cost of living in urban areas can lead to urbanization and expansion of cities into natural landscapes. This transformation of land use frequently leads to the fragmentation of habitats and disrupts wildlife corridors, limiting the movement of species and reducing gene flow between populations (McKinney, 2008). On the contrary, regions that are characterized by lower cost of living may have less financial capacity for conservation efforts and implementation of sustainable practices. Lack of funding can

impede conservation initiatives, leading to further biodiversity loss in these areas (Kideghesho, 2008).

The capacity of human populations to adjust to the challenges presented by climate change may indeed yield significant implications for the preservation of biodiversity. Climate change has the potential to bring about alterations in temperature, precipitation patterns, and extreme weather phenomena, which can have a direct impact on various ecosystems and the species they sustain. Ecosystems that exhibit greater adaptability are better suited to endure these variations, ultimately allowing biodiversity to persist. For instance, adaptable ecosystems may possess species that are capable of modifying their behavior, phenology, or distribution in response to fluctuating conditions. Climate change may exacerbate the effects of habitat fragmentation that result from anthropogenic activities. Fragmentation can isolate populations, diminish gene flow, and amplify the likelihood of local extinctions. Human adaptability in managing landscapes can aid in the creation of wildlife corridors and safeguarded areas that facilitate the movement of species, thus enhancing biodiversity conservation (Hannah et al., 2007). Climate change may expedite the proliferation of invasive species, which can outcompete or pose a direct threat to native species, resulting in biodiversity loss. Human adaptability plays a crucial role in monitoring and controlling invasive species, preventing their establishment, and rehabilitating ecosystems affected by their incursion (Hellmann et al., 2008). Climate change necessitates conservation planning that is dynamic and forward-looking. Adaptability in conservation strategies allows for the incorporation of changing climatic conditions and aids in the identification of areas likely to support species in the future, thereby augmenting the effectiveness of conservation efforts (Hannah et al., 2007).

Innovation is crucial in finding sustainable solutions that balance human needs with biodiversity conservation. Innovation drives advancements in resource management practices that reduce the environmental impact of economic activities. Sustainable practices, such as responsible fishing techniques, precision agriculture, and eco-friendly forestry methods, can help minimize the negative effects on biodiversity and ecosystem health (Costello et al., 2012). Technological innovations that promote clean energy, reduce emissions, and enhance energy efficiency can lead to a reduced ecological footprint. By transitioning away from fossil fuels and adopting renewable energy sources, we can mitigate the impacts of climate change, which is a significant driver of biodiversity loss (Creutzig et al., 2016). Innovative technologies such as remote sensing, drones, and genetic monitoring tools have revolutionized biodiversity conservation efforts. These technologies aid in data collection, and monitoring of species and habitats and help identify conservation priorities, leading to more effective conservation strategies (Andersson & Gaston, 2013). Innovation can promote the transition from a linear economy (take, make, dispose) to a circular economy, where resources are reused, recycled, and minimized waste. A circular economy reduces pressure on natural resources, helping to protect ecosystems and preserve biodiversity (Korhonen et al., 2018). Innovative approaches to tourism, such as eco-tourism and nature-based solutions, can provide economic opportunities while promoting biodiversity conservation. These approaches encourage sustainable tourism practices that support local communities and protect natural habitats (Balmford et al., 2009).

Innovation is of utmost importance when it comes to discovering sustainable solutions that balance the needs of humans with the conservation of biodiversity. The advancement in resource management practices, driven by innovation, aims to reduce the environmental impact of economic activities. The implementation of sustainable practices such as responsible fishing techniques, precision agriculture, and eco-friendly forestry methods can effectively minimize the harmful effects on biodiversity and ecosystem health (Costello et al., 2012). The promotion of clean energy, emission reduction, and enhanced energy efficiency through technological innovations can significantly decrease the ecological footprint. The mitigation of climate change,

which is a leading cause of biodiversity loss (Creutzig et al., 2016), can be achieved by switching from fossil fuels to renewable energy sources. The field of biodiversity conservation has experienced a revolution due to innovative technologies such as remote sensing, drones, and genetic monitoring tools. These technologies aid in data collection and monitoring of species and habitats, thus leading to the identification of conservation priorities and the development of more effective conservation strategies (Andersson & Gaston, 2013). The transition from a linear economy (take, make, dispose) to a circular economy, where resources are reused, recycled, and waste is minimized, can be facilitated by innovation. A circular economy can help reduce the pressure on natural resources, thereby protecting ecosystems and preserving biodiversity (Korhonen et al., 2018). Eco-tourism and nature-based solutions are examples of innovative approaches to tourism that can provide economic opportunities while promoting biodiversity conservation. These approaches encourage sustainable tourism practices that support local communities and protect natural habitats (Balmford et al., 2009).

The efficacy of regulatory establishments, encompassing governments, bureaus, and global organizations, assumes a pivotal function in configuring policies, enforcing regulations, and executing preservation approaches to protect biodiversity. Institutions of superior quality are better equipped to conceive and execute effective policies and regulations for the preservation of biodiversity. These institutions have the capacity to evaluate scientific proof, consider the input of stakeholders, and formulate comprehensive strategies to safeguard ecosystems and species (Young, 2002). Establishments with robust governance and regulatory potential can implement environmental laws and hold individuals and organizations liable for acts that endanger biodiversity. This enforcement assists in deterring illicit practices and mitigating threats to ecosystems (Keohane & Victor, 2011). Institutions of superior quality are critical for the efficient management of protected areas and conservation reserves. They ensure that these areas receive adequate funding, are competently managed, and offer sufficient safeguards for biodiversity (Leverington et al., 2010). Effective institutions invest in endeavors that cultivate capacity, such as training programs and educational initiatives, to enhance the knowledge and skills of conservation practitioners, researchers, and policymakers (James et al., 1999).

The correlation between economic expansion and enhanced GDP is frequently connected with amplified levels of resource extraction, land alteration, and contamination, which can substantially have an adverse impact on biodiversity. This correlation has been previously established by Sala et al. (2000). Heightened economic activity can contribute to pollution via industrial processes, transport, and energy production. The pollution generated affects both air and water quality, thereby leading to negative implications for biodiversity. Furthermore, increased greenhouse gas emissions arising from economic endeavors exacerbate climate change, thus posing a further threat to biodiversity through the modification of habitats and the disruption of ecological relationships, as highlighted by Steffen et al. (2011). The growth in the economy may lead to the overexploitation of natural resources, such as fish stocks, wildlife, and plant species. Practices that are not sustainable can result in population declines and loss of biodiversity, as pointed out by Worm et al. (2006). The augmentation in economic activity and globalization expedite the movement of goods and people, which might introduce invasive species to new regions. These invasive species could potentially outcompete native species and disturb ecosystem dynamics, leading to declines in biodiversity, as expounded by Hulme (2009).

Despite the comprehensive literature review conducted on the various factors influencing species habitat index and species protection index, there remains a significant research gap in the interplay between these determinants. While the existing studies have individually examined the impact of cost of living, climate change adaptability, innovation, quality of education, GDP, and institutional quality on biodiversity conservation, there is a lack of comprehensive research that explores their

combined and interactive effects on species habitat and protection across a wide range of countries and over an extended period. Most of the previous research has focused on specific regions or limited time frames, potentially overlooking broader patterns and long-term trends. Understanding how these factors interact and influence biodiversity conservation efforts is crucial for developing holistic and effective conservation strategies in the face of increasing global challenges. Therefore, this study aims to fill this research gap by providing a comprehensive and integrated analysis of the combined effects of cost of living, climate change adaptability, innovation, education quality, GDP, and institutional quality on species habitat and protection indices across multiple countries over an extended period from 2004 to 2021.

Methods and Data

Variables and Data Sources

Socioeconomic data on land use, population dynamics, economic indicators, and environmental variables will be collected from national statistical databases, published reports, and relevant research studies. This data will help identify the key socioeconomic determinants influencing biodiversity quality (Tabachnick & Fidell, 2019).

Table 1 shows the variables which are used in the study, here species habitat and species protection index are used as dependent indexes, determining the quality of biodiversity. The idea is to assess the social and economic factors of species habitation and government efforts to identify species protection areas. Based on the literature, 6 independent variables are selected in the study and discussed in Table 1.

The data is collected for 117 countries between 2004 and 2021. Since all countries do not have equal years of observations, this study constitutes an unbalanced panel data comprising of total 768 country-year observations.

Table 1: Variables and Data Sources

Name (Symbol)	Definition	Source
Species Habitat Index (SHI)	The proportion of suitable habitat species that remain intact as compared to the baseline of 2001 (>100 means habitat gain and <100 means habitat loss)	Map of Life Indicators
Species Protection Index (SPI)	How well the terrestrial protected areas overlap with the ranges of its vertebrate, invertebrate and plant species. (100 means full coverage and 0 means no overlap)	Map of Life Indicators
Cost of Living (CPI)	Consumer price index with base year 2015. (>100 means cost has increased, <100 means cost has decreased)	World Development Indicators
Climate Change Adaptability (GAIN)	It measures the readiness to leverage investments to adaptation actions	Notre Dame Global Adaptation Country Index
Innovation (INNO)	Index of indicators of innovation at national level	World Economic Forum
Quality of Education (QOE)	Country average of quality of education survey (1 Worst – 7 Best)	World Economic Forum

Economic Activity (GDP)	GDP per capita US\$ baseyear 2005. (Natural Log form)	World Development Indicators
Institutional Quality (INST)	Index of indicators of institutional quality at national level	World Economic Forum

Model and Methods

This research paper adopts a quantitative methods approach to investigate the socioeconomic determinants of biodiversity quality on land (Creswell & Plano Clark, 2018; Miles, Huberman, & Saldaña, 2019). The collected quantitative data will be analyzed using statistical methods such as correlation and regression analysis. This analysis will help identify the relationships between socioeconomic variables and biodiversity quality indicators (Tabachnick & Fidell, 2019).

$$SHI_{it} = \alpha_0 + \alpha_1 CPI_{it} + \alpha_2 GAIN_{it} + \alpha_3 INNO_{it} + \alpha_4 QOE_{it} + \alpha_5 GDP_{it} + \alpha_6 INST_{it} + e_{it} \quad (1)$$

$$SPI_{it} = \beta_0 + \beta_1 CPI_{it} + \beta_2 GAIN_{it} + \beta_3 INNO_{it} + \beta_4 QOE_{it} + \beta_5 GDP_{it} + \beta_6 INST_{it} + v_{it} \quad (2)$$

Equation 1 and 2 are stochastic versions that this study will estimate. While Equation 1 estimates the social and economic factors of biodiversity deterioration, equation 2 indicates the social and economic factors of human efforts to protect biodiversity. Hence they are de facto and de jure indicators of biodiversity quality. Under the sustainable practices hypothesis, this study proposes that other than CPI, all variables should positively affect SHI and SPI.

In order to estimate the unbalanced panel data model, this study has used Feasible Generalized Least Squares (FGLS) approach. This model is a generalized version of the Fixed effect model, which has the capability to be robust against time series heteroskedasticity and autocorrelation. A study by Arshed et al. (2021) estimated this model in a similar equation setup.

Results and Discussions

Table 2 provides the descriptive statistics of the data. We can see that CPI is over-dispersed as its mean value is smaller than standard deviation while all others are under-dispersed. While comparing skewness and kurtosis values, it can be seen that the data is not statistically normal. Thus study avails the central limit theorem to assume that the data is asymptotically normal.

Table 2: Descriptive Statistics

Stats	SHI	SPI	CPI	GAIN	INN	QES	GDP	INST
Mean	84.49	69.19	68.48	49.47	3.47	3.81	9.14	4.10
Median	90.99	78.49	59.86	46.90	3.23	3.67	9.22	3.89
Std. Dev.	14.89	29.82	308.81	10.85	0.85	0.92	1.21	0.87
Skewness	-2.65	-0.71	53.05	0.51	1.06	0.42	-0.10	0.59
Kurtosis	11.94	2.24	3133.59	2.49	3.40	2.51	2.13	2.40

Table 3 provides the linear association between the variables, here we can see that the selected variables correlate with the SHI and SPI while their pairwise correlation is less than 0.9, denoting the variance inflation factor to be less than 10. This rule out the likelihood of multicollinearity (Gujarati, 2022).

Figure 1 shows that an increase in cost of living is negatively associated with the species habitat index and positively associated with the species protection index. Several reasons discussed in the literature pointed out that a higher cost of living disturbs the ecosystem while it increases governments' efforts to protect endangered species.

Table 3: Correlations

	SHI	SPI	CPI	GAIN	INN	QES	GDP	INST
SHI	1.00							
SPI	-0.13	1.00						
CPI	-0.11	-0.04	1.00					
GAIN	0.11	0.25	-0.22	1.00				
INN	0.06	0.30	-0.16	0.81	1.00			
QES	0.12	0.23	-0.10	0.66	0.78	1.00		
GDP	0.07	0.21	-0.23	0.88	0.67	0.57	1.00	
INST	0.16	0.22	-0.16	0.77	0.82	0.79	0.69	1.00

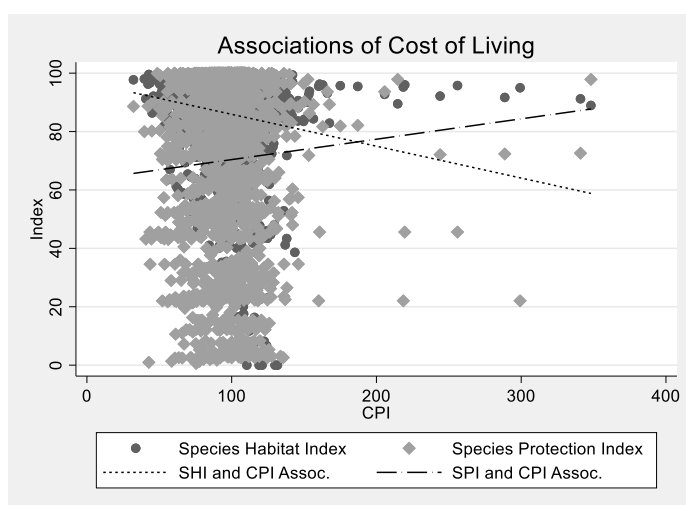


Figure 1 – Biodiversity Quality and Cost of Living

Figure 2 discusses the association between climate change adaptability and biodiversity quality. Here adaptability is positively associated with species protection, while there is no apparent association with species habitat index.

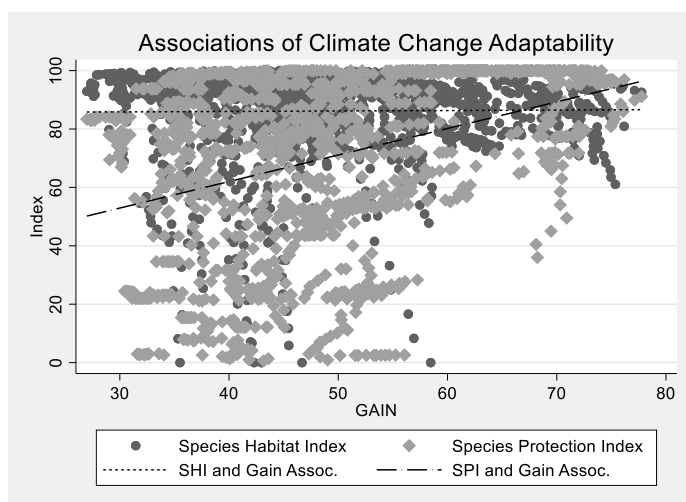


Figure 2 – Biodiversity Quality and Climate Change Adaptability

Figure 3 compares the changes in innovation with biodiversity quality. Here increase in innovation is positively associated with the species protection index, while no association is shown with the

species habitat index. Figure 4 denotes that increased education quality has a positive association with species habitat and species protection index.

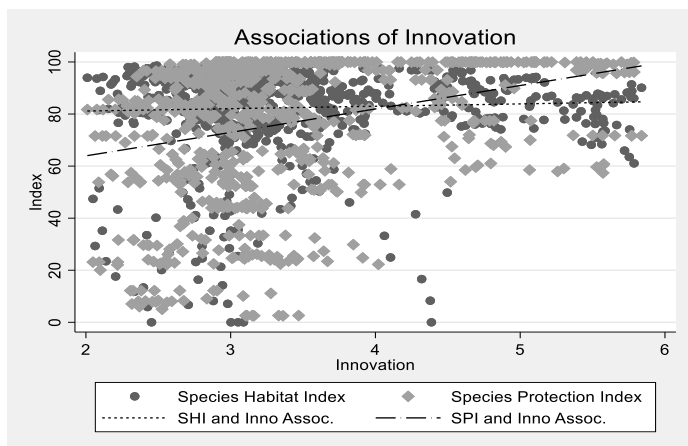


Figure 3 – Biodiversity Quality and Innovation

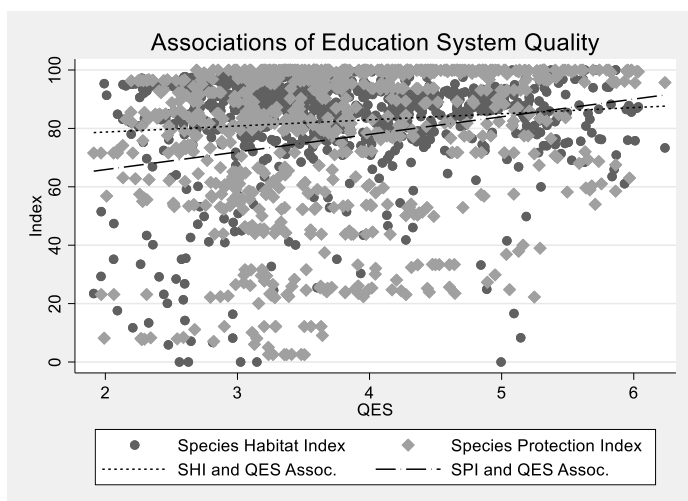


Figure 4 – Biodiversity Quality and Education System Quality

Figure 5 compares economic activity with biodiversity quality. It is noted that an increase in GDP per capita has a positive association with the species protection index, while it has no association with the species habitat index. But in Figure 6, better institutions tend to associate with species protection and species habitat index positively.

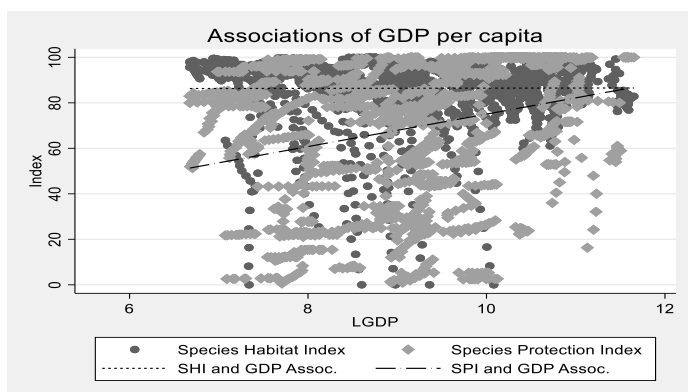


Figure 5 – Biodiversity Quality and Economic Activity

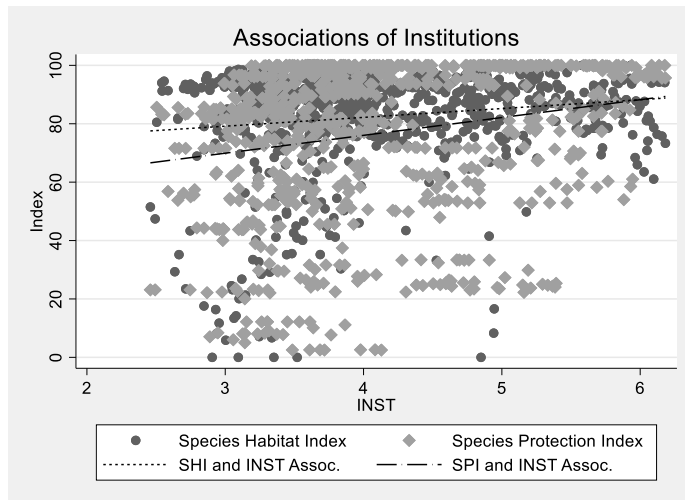


Figure 6 – Biodiversity Quality and Institutional Quality

Regression estimation results are quoted in Table 4, corresponding to equations 1 and 2. Here the sample size is 768 country-year observations using 117 countries. The Wald test value is significant in both estimates indicating that the models are fit in determining the changes in the SHI and SPI.

The intercept values are positive, while there is a fall in SHI and SPI. This shows that this study has correctly identified the generalized biodiversity-hindering factors nationally. Appropriately intervening with them would help in sustaining and improving biodiversity.

Here for the case of CPI, a 1% increase in CPI leads to 0.16% in SHI while a 0.04% increase in SPI. This indicates that higher cost destroys natural habitat because of increased pressure on resource extraction (Lawrance et al., 2014, while it increases the urgency for biodiversity conservation efforts (Kideghesho, 2008).

Table 4: Panel FGLS Estimates

	Dep. Var. = SHI		Dep. Var. = SPI	
Variables	Coef.	Prob.	Coef.	Prob.
CPI	-0.16	0.00***	0.04	0.04**
GAIN	0.47	0.00***	0.01	0.86
INNO	-5.06	0.00***	9.51	0.00***
QES	0.76	0.07*	1.12	0.02**
GDP	-4.89	0.00***	2.27	0.00***
INST	4.63	0.00***	-3.86	0.00***
Constant	119.45	0.00***	30.42	0.00***
Sample	768		768	
Cross sections	117		117	
Wald Chi ²	423.1	0.00***	3772.6	0.00***

*** significant at 1%, ** significant at 5% and * significant at 10%

Here for the case of CPI, a 1% increase in CPI leads to 0.16% in SHI while a 0.04% increase in SPI. This indicates that higher cost destroys natural habitat because of increased pressure on resource extraction (Lawrance et al., 2014, while it increases the urgency for biodiversity conservation efforts (Kideghesho, 2008).

For the case of climate change adaptation, a 1% increase in adaptation leads to a 0.47% improvement in SHI, while it does not affect SPI. Improvement in adaptation improves the resilience of the ecosystem, which supports the species' habitation (Hannah et al., 2007).

For the case of innovation, a 1% increase in innovation leads to a 5.06% increase in habitat destruction (SHI), while it also has a 9.51% increase in habitat protection (SPI). The results show that, on one side, innovation helps in protecting the ecosystem using improvements in conservation technologies (Andersson & Gaston, 2013). But on the other side, the scale effect of innovation is economic growth, which increases the demand for national resources that disturb the ecosystem (MEA, 2005; Lambin & Meyfroidt, 2011). This effect is opposite to the expected positive effect under the sustainable practices hypothesis.

For the case of quality of education, a 1% increase in education quality leads to a 0.76% increase in SHI and a 1.12% increase in SPI. Better education improves environmental awareness and sustainable practices, which helps conserve the ecosystem (Bonney et al., 2009). Further, it helps develop appropriate policies and advocacies to protect ecosystems (Steg & Vlek, 2009).

For the case of economic activity (GDP), a 1% increase in GDP reduces SHI by 4.89% and improves SPI by 2.27%. This means that economic activity increase will increase natural resource utilization leading to the deterioration of the ecosystem (Sala et al., 2000; Lambin & Meyfroidt, 2011). But it also increases the capacity to develop infrastructure to protect biodiversity (Kideghesho, 2008).

Lastly, for the case of institutional quality, a 1% improved institution would improve SHI by 4.63% but reduce SPI by 3.86%. Better institutions help in providing a platform for public engagement in biodiversity conservation (Reed, 2008). But pursuing overregulation may hinder biodiversity conservation efforts because of prioritizing flagship species over less-known species, exclusion of best practices of indigenous groups (Agarwal & Redford, 2006) and bureaucratic delays in rapid responses to emerging threats. This effect contradicts the expected positive effect under the sustainable practices hypothesis.

Conclusion and Policy Implications

Biodiversity protection is paramount due to its critical role in maintaining ecological balance, providing ecosystem services, and supporting human well-being. The information presented in this analysis underscores the need for research and conservation efforts focused on biodiversity. Various factors, such as cost of living (CPI), climate change adaptation, innovation, quality of education, economic activity (GDP), and institutional quality, have different impacts on the species habitat index (SHI) and the species protection index (SPI). These findings highlight the complex interplay between human activities, conservation practices, and their effects on the ecosystem and species survival. Conducting further research on biodiversity conservation is essential to develop more effective strategies and policies that address the negative impacts of certain factors while maximizing positive contributions to species protection and habitat preservation.

This study used the discussed independent variables for 117 countries to explore the social and economic factors on de facto and de jure indicators of biodiversity quality. The panel data analysis using FGLS model listed significant indicators and provided interesting outcomes. Most of the results comply to the empirical studies, while the outcomes of institutional quality and innovation are surprising and demand further research and rectification.

The findings from the analysis offer valuable insights for policy formulation and decision-making to enhance biodiversity conservation efforts. Firstly, policies should prioritize education quality enhancement to raise environmental awareness and foster sustainable practices among the public.

Education plays a crucial role in promoting a conservation-oriented mindset and encouraging responsible resource use. Secondly, there is a need for careful consideration of economic growth and innovation. While economic activity can provide opportunities for biodiversity protection through infrastructure development, it should be balanced with measures to mitigate its negative impacts, such as habitat destruction and increased resource extraction. Thirdly, policies should focus on strengthening institutional quality to improve species habitat index, but they should also ensure inclusivity and sensitivity to the needs of local communities and indigenous groups. In doing so, overregulation and biased prioritization can be avoided, fostering more effective and equitable conservation outcomes. Lastly, climate change adaptation should be integrated into conservation policies to enhance ecosystem resilience and support species' habitation in the face of changing environmental conditions. By incorporating these policy implications, we can strive towards a more sustainable and harmonious coexistence with nature while safeguarding the invaluable diversity of life on Earth.

It is important to acknowledge the limitations of the study. The research may face limitations related to the length of data availability. Though efforts are being made to minimize these limitations using robust analysis, future studies can explore specific anthropogenic factors in determining species resilience.

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