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Biodiversity Conservation and Species Survival: An Ecological Study

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ABSTRACT

Biodiversity loss is one of the world's most pressing environmental issues in the 21st century. This research examines the ecological perspectives on biodiversity conservation and species survival, based on the scientific literature from global assessment reports, conservation policy research and global ecological research. This study first considers the key drivers of biodiversity loss, which are pollution, invasive species, habitat loss, climate change and overexploitation, and how they have combined to affect ecosystem resilience, stability and function. It then assesses the effectiveness of a number of biodiversity conservation efforts, such as protected areas, ex situ conservation, community conservation, and biotechnologyThis paper's analysis draws on information from the IPBES Global Assessment (2019) and IUCN Red List (2023). The study concludes that an ecological perspective that includes indigenous knowledge is required for a paradigm shift in policy to be able to reverse the current biodiversity loss.

Keywords— secosystem services, IUCN Red List, conservation ecology, habitat degradation, species extinction, biodiversity.

1. Introduction

Biodiversity, the diversity of organisms' genes, the diversity of species, and the diversity of ecosystems, is the material basis upon which ecology and human societies are founded. Yet, during the current geological period, the Anthropocene, humanity is purposefully destroying biodiversity at a rate not seen since the end of the Cretaceous Period. In the IPBES's landmark report published in 2019 that it was estimated that over one million species are likely to go extinct within a few decades and many within the lifetime of current generations.[1]

[1]Intergovernmental Science-Policy Platform on biodiversity and ecosystem Services (IPBES), Global Assessment Report on biodiversity and ecosystem Services (Bonn: IPBES Secretariat, 2019), 12.

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The rate of extinction is many orders of magnitude higher than the natural background rate, according to naturalist E. O. Wilson, who coined the term "biodiversity crisis. Wilson described this phenomenon as a type of biological impoverishment that has no historical precedent in the human era.[2] But these extinctions represent the breakdown of the biological basis upon which freshwater supplies, food security, climatic stability, disease control, and trade are all based. Consequently, the rapid extinction of species and ecosystems requires a detailed examination based on scientific principles, and, more importantly, effective policy measures.

This paper offers a thorough ecological assessment of biodiversity preservation and species sustainability on land, freshwater, and marine environments. The paper provides an overview of extinction trends in terms of ecological and evolutionary theory, considers major factors of anthropogenic nature causing biodiversity depletion, analyzes effectiveness of local to overseeing conservation initiatives. Through the application of empirical results based on credible scientific literature and official worldwide statistics on biodiversity, the research is anticipated to contribute to the scholarly conversation regarding strategies for balancing economic expansion and biological conservation in human society.

2. Depletion of Biodiversity: A Statistical Analysis

2.1 Global Extinction Rate

It is estimated that extinction rates now are between 100 and 1,000 times greater than those recorded in the fossil record. The result was validated using many independent methods.[3] The IUCN Red List of Threatened Species is the most reliable resource for information on the condition of organism conservation worldwide. In its 2023-1 edition, the list assessed some 150,000 species, with over 42,100 of these evaluated as being threatened with extinction.[4] The rate of extinction of birds and mammals with humans is thought to be about 100 times the rate without human disturbance. But the rate of extinction of relatively obscure invertebrates and plants, based on the same calculation, shows the rate of extinction at a much larger scale than stated above [5]

As per noted by Richard Primack, our conservation efforts may be too little, too late due to the fact that many species become extinct even before they can be discovered by scientists.[6] Most of the 8.7 million species of life on Earth are yet to be discovered and their functions in the natural ecosystems in which they live, such as decomposition, nutrient cycling, pollination, pest control, and pathogen buffer, are unknown. As such, they play a vital role in the ecosystem, and their extinction would have a cataclysmic impact

[2]E. O. Wilson, The Diversity of Life (Cambridge, MA: Harvard University Press, 1992), 280.

[3]IPBES, Global Assessment Report, 14.

[4]IUCN, The IUCN Red List of Threatened Species, Version 2023-1 (Gland: IUCN, 2023), accessed February 2024, https://www.iucnredlist.org.

[5]Stuart L. Pimm et al., "The Biodiversity of Species and Their Rates of Extinction, Distribution, and Protection," Science 344, no. 6187 (2014): 1246752.

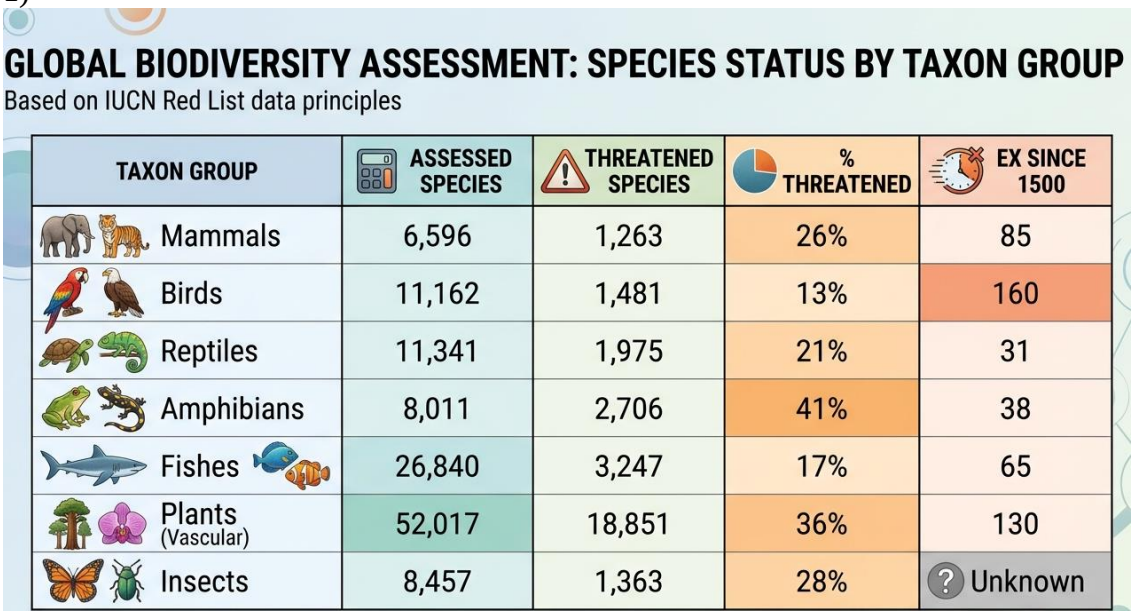
[6]Richard Primack, A primer of conservation biology, 5th ed. (sunderland, MA: Sinauer Associates, 2012), 47.

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Table #01: major taxon group conservation status on the IUCN red list (version 2023-1)



GLOBAL BIODIVERSITY ASSESSMENT: SPECIES STATUS BY TAXON GROUP

Based on IUCN Red List data principles

TAXON GROUP	ASSESSED SPECIES	THREATENED SPECIES	% THREATENED	EX SINCE 1500
Mammals	6,596	1,263	26%	85
Birds	11,162	1,481	13%	160
Reptiles	11,341	1,975	21%	31
Amphibians	8,011	2,706	41%	38
Fishes	26,840	3,247	17%	65
Plants (Vascular)	52,017	18,851	36%	130
Insects	8,457	1,363	28%	Unknown

Data has taken from IUCN red list of threatened Species, version of 2023/1 (gland: IUCN, 2023). "EX" represents a species that is known to be extinct since 1500 CE.

2.2sixth mass extinction

Five previous waves of extinction have occurred in the geological history of Earth, with extinction rates exceeding 75 percent of all species occurring during relatively short periods of time. Paleontological records and current biodiversity levels demonstrate that the current human extinction wave is the sixth mass extinction event on Earth.[7] The Aichi Biodiversity Targets were set in 2010 and, according to the Convention on Biological Diversity's Global Biodiversity Outlook 5, biodiversity has declined in almost all indicators in the past decade. None of the twenty targets under the framework of the Aichi Biodiversity Targets were achieved by 2020.[8] So, in response to the global policy framework's failure to achieve set targets, it is time to adopt new paradigms for biodiversity management, which would address root socioeconomic causes, rather than symptoms.

3. Biodiversity and ecosystem facilities

The concept of ecosystem services, that is, the advantages that nature offers to people independent of their commercial value is the foundation of the utilitarian case for biodiversity protection. Consequently, Costanza et al estimated that the value of all ecosystem services on Earth was approximately US$33 trillion per year, an amount higher than the global gross national product at that time and subsequently adjusted

[7]Convention on biological diversity, global biodiversity outlook 5 (Montreal: CBD Secretariat, 2020), 8.

[8]Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: Synthesis (Washington, DC: Island Press, 2005), 3.

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upwards.[9] There is extensive experimental research on the functional role of species richness in ecosystem performance. For example, Tilman et al, via grassland biodiversity experiments, proved that species-rich plots had higher rates of productivity, more efficient nutrient retention, and more resistance to perturbations compared with species-poor communities.[10]

There is extensive experimental research on the functional role of species richness in ecosystem performance. For example, Tilman et al, via grassland biodiversity experiments, proved that species-rich plots had higher rates of productivity, more efficient nutrient retention, and more resistance to perturbations compared with species-poor communities.[11] Naeem et al proved that decreases in biodiversity resulted in decreased ecosystem functioning and consequently reduced provision of ecological services. Finally, a synthesis study conducted by Cardinale found lastly, a synthesis analysis by Cardinale discovered that 192 empirical studies showed a detrimental impact of declining biodiversity on biomass production, resource capture and recycling, and ecological regulation mechanisms.[12]

The previous concept is expanded upon by the biodiversity theory of insurance, which claims that ecosystems with a greater number of species would have higher functional stability due to different responses by different species to environmental perturbations and their ability to functionally balance each other out. Isbell et al. confirmed through empirical research that high plant diversity is required to sustain many ecosystems at once, where extinction of certain species leads to deterioration of the provided services despite functional redundancy.[13] The above redundancy effect becomes especially important in face of rapid climatic changes, intensifying environmental variability that biological communities need to withstand.

4. Major Causes of Biodiversity Loss

4.1 Destruction and Fragmentation of Habitats

According to the IUCN Red List, habitat degradation, fragmentation, and destruction are responsible for up to 85% of the extinction of species that are listed as vulnerable.[14] Animal and plant populations become isolated within parts of their original range as a result of habitat alteration or loss brought about by the building of towns, highways, farms, and industrial sites, making dispersal, gene flow, and migration difficult and effectively decreasing population size and genetic diversity effects population sizes,

[9]Robert Costanza et al"the Value of the world's ecosystem services and natural capital," nature 387 (1997): 253.

[10]Gretchen C. Daily, ed., Nature's Services: Societal Dependence on Natural Ecosystems (Washington, DC: Island Press, 1997), 10.

[11]David Tilman et al., "Biodiversity and Ecosystem Functioning," Nature 405 (2000): 208.

[12]Bradley J. Cardinale et al., "Biodiversity Loss and Its Impact on Humanity," Nature 486 (2012): 60.

[13]Forest L. Isbell et al., "High Plant Diversity Is Needed to Maintain Ecosystem Services," Nature 477 (2011): 199.

[14]David S. Wilcove et al., "Quantifying Threats to Imperiled Species in the United States," BioScience 48, no. 8 (1998): 608.

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and intensifying the demographic and genetic stochasticity that characterizes extinction-prone populations.

The Amazon Basin, home to about 10 percent of all living things on Earth, provides a compelling example of the worldwide habitat crisis. According to Lovejoy and Nobre's findings, the Amazon is approaching the tipping point of dieback at 20 to 25 percent deforestation, after which it will turn into a savanna due to the combined effects of deforestation and regional climate change and the release of stored carbon would be inevitable, leading to catastrophic consequences for regional biodiversity and the world's climate system.[15] Lovejoy et al. demonstrated that even within formally protected areas, The consequences of edge effects, hunting, logging, fires, and other human disturbances within the protected zones are the main causes of the evidence of decreased biodiversity.[16]

4.2 climate change

Climate change has identified as an increasingly important factor contributing to biodiversity loss, and it is expected to become more significant than habitat destruction in causing species' extinctions before mid-century.[17] According to Thomas et al., climate change alone may cause 15 to 37 percent of studied species to go extinct by 2050 owing to habitat range reduction or total extinction at moderate levels of warming.[18] Many species in different taxonomic categories have already been reported to shift their range towards higher latitudes and elevations at an average speed of around 17 km per decade and their phenology at an average pace of around 5.1 days per decade in response to warming, according to Chen et al.[19]

Marine ecosystems are threatened by a number of factors, including ocean warming, acidification and deoxygenation. Bleaching has led to substantial losses in coral reefs over the last few decades. Warming of only 2° Celsius would likely result in annual catastrophic bleaching of almost all warm water coral reefs, which would make it challenging for these ecosystems to thrive without immediate intervention.

4.3 Alien Invasive Species

Biological invasions have caused the extinction of more than 40% of animal species since 1500, and are the second most frequent cause of animal extinction. Invasive species have harmed native species through predation, competition, hybridization, virus transmission and ecosystem engineering.[20] Because of the naivety of their evolution

[15]Thomas E. Lovejoy and Carlos Nobre, "Amazon Tipping Point," Science Advances 4, no. 2 (2018): eaat2340.

[16]William F. Laurance et al., "Averting Biodiversity Collapse in Tropical Forest Protected Areas," Nature 489 (2012): 290.

[17]Camille Parmesan, "Ecological and Evolutionary Responses to Recent Climate Change," Annual Review of Ecology, Evolution, and Systematics 37 (2006): 638.

[18]Chris D. Thomas et al., "Extinction Risk from Climate Change," Nature 427 (2004): 145.

[19]I-Ching Chen et al., "Rapid Range Shifts of Species Associated with High Levels of Climate Warming," Science 333, no. 6045 (2011): 1024.

[20]Jessica J. Hellmann et al., "Five Potential Consequences of Climate Change for Invasive Species," Conservation Biology 22, no. 3 (2008): 534.

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without mammals as natural adversaries, the flora and fauna of islands are especially vulnerable. The plant and animal life of islands are particularly at risk, due to the naivety of their evolution without exposure to mammals as enemies. The loss of more native island species to rats, cats, pigs, and mongooses is than to any other single factor. The Nile perch (Lates niloticus) was introduced into Lake Victoria in the 1950s and led to the extinction of more than 200 native cichlid species in a few decades. [21]

4.4 Pollution and Overexploitation

Numerous species are still becoming extinct or functionally extinct due to over-slaughter, harvest or poaching. With efforts to capture marine fish increasing, marine fish captures began to decline in the 1990s, suggesting that almost all commercially valuable species are being overfished. Plummeting levels of African elephants, rhinoceros, pangolins, reptiles and amphibians due to terrestrial wildlife trade and poaching have left them at critically low levels, with significant implications for their ecosystems. In all ecosystems, organisms are stressed by chemical pollution, eutrophication, plastics, endocrine disruptors, light pollution, and noise pollution. There is strong evidence that neonicotinoids are to blame for the decrease in pollinator insect populations, which is significant enough to affect the ecological services these creatures perform.[22]

5. Conservation Strategies: Assessment and Validation

5.1 In-situ Conservation and Protected Areas

The global protection of biodiversity depends heavily on protected areas. The International Union for protection of Nature (IUCN) defines a protected area as any geographical region that has been formally or practically formed with the goal of achieving the long-term protection of nature and the services and values that go along with it.[23] Approximately 8% of marine habitats and 17% of terrestrial regions have some sort of protected status by 2023. However, there are significant differences in the effectiveness of protection enforcement between political jurisdictions, the degree to which these regions are protected, and the uneven allocation of conservation financing. It is commonly known that properly maintained protected areas may considerably slow the loss of biodiversity. On paper, though, protection is not the same as biodiversity conservation. When compared to unprotected areas, paper parks—that is, formally recognized places without active management or enforcement—consistently show no conservation impacts. The geographical layout of protected area networks is also very important: although well-connected networks with intact wildlife corridors can support metapopulation dynamics and enable climate-driven range changes, isolated reserves eventually lose species due to island biogeographic processes.

[21]Kevin J. Gaston and Tim M. Blackburn, Pattern and Process in Macroecology (Oxford: Blackwell Science, 2000), 123.

[22]William J. Sutherland et al., "One Hundred Questions of Importance to the Conservation of Global Biological Diversity," Conservation Biology 23, no. 3 (2009): 558.

[23]Nigel Dudley, ed., Guidelines for Applying Protected Area Management Categories (Gland: IUCN, 2008), 3.

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5.2 Ex-situ Preservation

Ex-situ conservation, which employs gene banks, botanical and zoological gardens to conserve species outside of their natural environments, is an important "off-site" strategy for biodiversity. For instance, the Svalbard Global Seed Vault, which stores backups of some 1.3 million seed varieties to ensure against the loss of agriculture, is part of this global network. Although essential, there are biological dangers associated with this strategy. Captive-managed populations frequently only reflect a small portion of a species' overall genetic diversity, as stated by Frankham et al. Long-term care in artificial environments can also lead to "domestication" effects and inbreeding depression, which may make it more difficult for these species to thrive if they are ever released back into the wild.[24] So, rather than being a substitute for the conservation of ecosystems, ex-situ approaches are a form of insurance.***5.3* Conservation Strategies: Evaluation and Validation**

5.1 In-situ conservation and protected areas

Ex-situ conservation, which employs gene banks, botanical and zoological gardens to conserve species outside of their natural environments, is an important "off-site" strategy for biodiversity. For instance, the Svalbard Global Seed Vault, which stores backups of some 1.3 million seed varieties to ensure against the loss of agriculture, ***is part of this global network***.[2526]. So, rather than being a substitute for the conservation of ecosystems, ex-situ app***roaches are a form of insurance***.

5.4 Restoration and rewilding

To return ecosystems to their natural state, researchers are now increasingly turning to rewilding that involves the reintroduction of keystone or top predators and disturbance. For example, when wolves (Canis lupus) were reintroduced at Yellowstone National Park in 1995, the changes caused by the wolves represented a textbook example of a trophic cascade, in which the wolves' predation kept vegetation on the banks in check, ultimately creating a more habitable environment for beavers, songbirds, and rivers.[27] Large-scale rewilding projects such as the Rewilding Europe project are underway in Europe to see if this can be done in human-impacted farming landscapes.

5.5 Genomic Conservation and Biotechnology

Conservationists now have more tools at their disposal because to the development of conservation genomics, which includes methods like whole genome sequencing, eDNA metabarcoding, and genetic rescue utilizing CRISPR technology.[28]Carroll et al. have demonstrated that genetic characteristics such population connectedness, inbreeding

[24] Richard frankham, jonathan D. ballou and David A. Briscoe, Introduction to Conservation Genetics, 2nd ed. (Cambridge: Cambridge University Press, 2010), 243.
[25] Alexander Mosseler, Jana E. Egger, and Glenn A. Hughes, "Small Population Size and the Risk of Local Extinction," Forestry Chronicle 68, no. 3 (1992): 347.
[26] Yvette Collier and Michael J. Lace, "CAMPFIRE: A Case Study in Community-Based Natural Resource Management in Zimbabwe," Society & Natural Resources 9, no. 2 (1996): 118.
[27]Reed F. Noss and Allen Y. Cooperrider, Saving Nature's Legacy: Protecting and Restoring Biodiversity (Washington, DC: Island Press, 1994), 5.
[28]Carroll et al., "Genetic and Genomic Monitoring," 1095.

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coefficients, and adaptive genetic diversity may be evaluated using minimally invasive genomics without the use of highly intrusive or destructive sampling techniques. While the prospect of genomic de-extinction is exciting, the majority of conservation biologists have warned that this encouraging outlook should not diminish the need to focus on protecting existing species.

Table 2: visual diagram of the comparative evaluation of principal conservation techniques



Source: data has taken from Compiled from main conservation literature, Frankham et al. (2010), Collier and Lace (1996), CBD (2022), and IUCN (2008).

6. international policy and their limitations

The Convention on Biological Diversity (CBD, 1992), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1973), and the Ramsar Convention on Wetlands (1971) are the three main international -treaties that make up the global biodiversity governance regime. The ambitious "30×30" objective to conserve at least 30% of land and sea areas by 2030 was set by the CBD's Kunming-Montreal Global Biodiversity Framework, adopted in December 2022 at COP 15. It also committed to addressing pollution, eliminating US$500 billion in biodiversity-destroying subsidies each year, and providing financial resources for biodiversity protection in developing countries.[29]

The most successful national biodiversity conservation law so far is the United States' Endangered Species Act (ESA, 1973), which effectively guarantees that none of the listed species have disappeared since then. But the ESA has not fared well in recovering endangered species to the extent that their protection can be removed, according to

[29]Convention on Biological Diversity, Kunming-Montreal Global Biodiversity Framework (Montreal: CBD Secretariat, 2022), 6.

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Schwartz's analysis. This was because of a lack of recovery plans, lack of resources, and opposition from land use economic interests.[30]

Although the utilitarian approach to justifying biodiversity conservation based on quantifiable quantities of ecosystem services is often politically feasible, Chan et al. it remains inherently inadequate, as it relies on a pragmatic and anthropocentric argument in favor of nature, rather than on an intrinsic value of nature and the relational values associated with human understanding of its place within the environment.[31] The philosophical problem has direct implications for practice, since organisms and ecosystems that offer fewer tangible services will tend to be systematically underrepresented in biodiversity conservation policy decisions that involve cost-benefit evaluations.

7. Holistic Conservation Approach

Moving Towards an Integrated Conservation Strategy

The evidence outlined above indicates that modern conservation for biodiversity cannot be achieved by conservation of habitat in isolation from more holistic socio-economic transformation of the landscape, or by piecemeal strategies, in which individual organisms are considered in isolation. Fischer et al. argue that resilience (designing systems to be less vulnerable to shocks and to rearrange in new ways), spatial planning, adaptive management and political economy are all needed for effective conservation.[32]

There should be several aspects to the structure. First, it needs to be spatially coherent, which means that protected areas should be designed and thought of as interconnected landscapes with wildlife corridors and matrix habitats in high-quality states that facilitate species dispersal under climate-induced range shifts rather than as isolated pockets. Second, it should be governance pluralistic, which means that since research indicates that multiple governance regimes outperform any one regime in isolation, state-based protection regimes must be complemented by indigenous territorial claims, co-management structures, and incentive-based private conservation initiatives. Lastly, it should be economically revolutionary, which means that subsidies that are detrimental to conservation must be changed or eliminated completely, In order to bridge the $700 billion yearly conservation financial gap indicated by the CBD, creative funding alternatives including biodiversity credits, payments for ecosystem services, debt-for-nature swaps, and green bonds need be extensively implemented.

Fourth, educational initiatives, citizen science, the incorporation of indigenous knowledge, and participatory decision-making that goes beyond technocratic methods based only on expertise are necessary to address the embedding into society, the consideration of values, ethics, and cultures related to the relationship with nature.

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[30]Mark W. Schwartz, "The Performance of the Endangered Species Act," Annual Review of Ecology, Evolution, and Systematics 39 (2008): 279.

[31]Kai M. A. Chan et al., "Why Protect Nature? Rethinking Values and the Environment," Proceedings of the National Academy of Sciences 113, no. 6 (2016): 1462.

[32]Joern Fischer et al., "Integrating Resilience Thinking and Optimisation for Conservation," Trends in Ecology and Evolution 24, no. 10 (2009): 549.

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The Kunming-Montreal framework is the best multilateral attempt ever made to conserve biodiversity, but its success will primarily depend on private sector compliance and national and subnational implementation, both of which have historically been plagued by a huge gap between aspiration and reality. In addition to technical advancements, this gap may be closed by shifting political and economic objectives to acknowledge the indisputable reality that biodiversity is the biological basis of human success rather than a luxury of affluent countries.

8. Conclusion

In this study, we have examined the ecological consequences of species survival and biodiversity preservation at different levels of biological and political organization. It is undeniable that humans are to blame for the current extinction crisis, that it is occurring at an alarming rate, making it the sixth extinction episode in geological history, and that the ensuing ecological consequences coming from the deterioration of ecosystem processes, destabilization of food webs and decline in adaptability due to rapid climate change will negatively impact human beings irrespective of the place and socio-economic backgrounds.

The best strategy for dealing with biodiversity conservation includes spatial protection and ecological restoration together with empowerment of communities and genetic preservation along with socio-economic reformations. No single silver bullet is the name of the game is the nature of the problem requires bringing together resilience, landscape ecology, governance and political economy in an effective strategy for conservation.

Most significantly, the relationship between human civilizations and the living world must drastically shift from one based on exploitation to one based on stewardship in order to conserve biodiversity. The science required to accomplish this objective is accessible and constantly developing. What is lacking, though, is the institutional and political capacity and inclination to implement it. According to this viewpoint, the scientific study of biodiversity protection is essentially an investigation of the circumstances surrounding human presence on Earth.