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Research Article

Aligning regional and international biodiversity conventions to benefit butterfly conservation in Africa. A review

Gebreegziabher Hailay Gebrenariam[1*]

[1]*Ethiopian Biodiversity Institute, Addis Ababa, Ethiopia*

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ABSTRACT

African butterflies are essential for ecosystems but face threats. To protect them, aligning biodiversity conventions with specific butterfly conservation goals is crucial. This review aimed to optimize the alignment of regional and international biodiversity conventions for enhancing African butterfly conservation. To achieve this, I systematically assessed relevant conventions, their provisions, some success stories, and implementation effectiveness in Africa. A comprehensive search of academic databases and official convention resources was conducted using rigorous selection criteria to identify high-quality information directly related to butterfly conservation and the role of these conventions. Thus, international and regional biodiversity conventions offer a multifaceted approach to African butterfly conservation. The CBD provides a framework for biodiversity conservation, including identifying, monitoring, and conserving butterfly populations. The ACCNNR indirectly supports butterflies through sustainable resource use and habitat protection. Climate change poses a significant threat, but the UNFCCC can mitigate its impacts. CITES regulates butterfly trade, and its effectiveness can be enhanced through expanded coverage, aligned strategies, and sustainable farming initiatives. The Ramsar Convention, focusing on wetlands, can significantly enhance butterfly conservation by recognizing them as bioindicators and integrating their conservation into wetland management plans. And the World Heritage Convention protects crucial butterfly habitats. These conventions collectively contribute to butterfly conservation by promoting habitat protection, sustainable practices, public awareness, and international cooperation. International conventions have demonstrated their effectiveness in advancing African species conservation through collaborative initiatives. The KAZA TFCA and MDTFCA exemplify successful transboundary cooperation, showcasing how these agreements facilitate large-scale habitat conservation, promote species movement, and enhance research. International conventions are crucial for African butterfly conservation. By fostering cooperation and promoting habitat protection, they significantly contribute to safeguarding butterfly populations. However, resource constraints and data gaps hinder progress. To maximize impact, aligning national plans with international goals, investing in research, and strengthening community engagement are essential.

Key words: Africa, Butterfly, Conservation, Conservation efforts, Conventions, Framework

INTRODUCTION

African butterflies play a fundamental role in maintaining healthy ecosystems, particularly in tropical forests and grasslands where they serve as both pollinators and indicators of environmental health (Edge & Mecenero, 2015). These delicate insects contribute significantly to plant reproduction, including economically valuable crops, making them essential for both natural ecosystems and agricultural systems (Taron & Ries, 2015); (Forister et al., 2023). Their sensitivity to environmental changes makes them excellent bioindicators, with population fluctuations revealing the effects of habitat loss, pesticide use, and climate variations (Ubach et al., 2022). Recent research highlights concerning declines in African butterfly populations, where habitat fragmentation combines with climate stressors like drought and temperature extremes to create particularly challenging conditions for specialist species (Warren et al., 2021); (Chowdhury et al., 2022); (Bergerot et al., 2024).

The importance of butterflies extends far beyond their ecological functions. They contribute to local economies through ecotourism activities like butterfly-watching in places such as Kenya's Kakamega Forest, providing income opportunities for nearby communities (Munyuli, 2020). Additionally, various indigenous cultures incorporate butterflies into their traditional practices and medicinal knowledge, demonstrating their deep cultural significance (Pe'er & Settele, 2008). However, these valuable contributions face increasing threats from unsustainable land management practices and inadequate policy implementation (Taron & Ries, 2015).

Addressing these challenges requires a comprehensive, three-part strategy. First, habitat protection efforts must expand to include more protected areas and the restoration of critical wildlife corridors, with special attention to climate-resilient zones (Bonebrake et al., 2023). Second, community involvement should be prioritized through programs that engage local populations in monitoring efforts and promote butterfly-friendly agricultural techniques, building on successful models from Uganda (Dongmo et al., 2023). Third, policy frameworks need strengthening to better align national conservation plans with international agreements like the Convention on Biological Diversity (CBD) and

[*]*Corresponding Author's E-mail: gebreegziabherhailay4@gmail.com*

CITES, ensuring coordinated efforts across borders (Trouwborst et al., 2017); (Alvarado-Quesada & Weikard, 2017).

Innovative technologies, including artificial intelligence for species identification and advanced modeling for habitat conservation (Bergerot et al., 2024), present exciting opportunities to enhance these efforts. When combined with traditional ecological knowledge and effective governance structures, these approaches can help develop sustainable conservation models that protect butterfly populations while supporting local communities (Chandra & Idrisova, 2011). This integrated approach offers a promising path forward for preserving Africa's butterfly diversity and the many benefits it provides to both ecosystems and human societies.

While international and regional biodiversity conventions offer a framework for African butterfly conservation, their effectiveness links on a rigorous review and alignment of their objectives (Taron & Ries, 2015); (Trouwborst et al., 2017). This process fosters evidence-based decision-making for resource allocation (Trouwborst et al., 2017) and empowers advocates to bridge policy gaps for stronger protections and funding (Chandra & Idrisova, 2011). Furthermore, aligning local efforts with international goals strengthens their impact and aids conservation organizations in identifying funding mechanisms and raising awareness (Chandra & Idrisova, 2011). By assessing implementation effectiveness and highlighting areas for improvement, this review empowers stakeholders to refine strategies, prioritize actions, and demonstrate the transformative power of international collaboration. A review and alignment of these conventions, therefore, presents a valuable tool for optimizing butterfly conservation efforts in Africa.

REVIEW METHODOLOGY

Search strategy

To comprehensively assess how regional and international biodiversity conventions can better support African butterfly conservation, this review employed a multi-pronged approach. First, a systematic search across prominent academic databases (ScienceDirect, Web of Science, and Google Scholar) was conducted using relevant keywords such as "butterfly conservation," "biodiversity conventions," and "Africa." Second, the official websites of key biodiversity and conservation conventions (i.e. CBD, ACCNNR**,** UNFCCC, CITES, Ramsar Convention on Wetlands, the Basel Convention, and World Heritage Convention) were examined. This combined approach ensured a comprehensive review of both academic literature and official convention resources.

Selection Criteria

To ensure high-quality information, this review employed strict selection criteria. Sources directly addressing butterfly decline, conservation strategies, and the role of biodiversity conventions were prioritized. Peer-reviewed publications from credible institutions and recent years were favored. Website content accuracy and affiliation with reputable organizations were also considered. Finally, sources aligned with biodiversity conventions, exploring their effectiveness and potential improvements for butterfly conservation in Africa, were chosen.

OVERVIEW OF REGIONAL AND INTERNATIONAL BIODIVERSITY CONVENTIONS

Convention on Biological Diversity (CBD)

The Convention on Biological Diversity (CBD), adopted in 1992, serves as a global framework for the conservation and sustainable use of biodiversity, with its goals directly affecting efforts to protect African butterflies. Several key targets and goals within the CBD framework hold particular significance for butterfly conservation on the African continent (Convention on Biological Diversity (CBD, 1992). Article 7 emphasizes the importance of identifying and monitoring biodiversity, crucial for understanding butterfly populations and their habitats. Articles 8 and 9 promote in-situ and ex-situ conservation, respectively, vital for protecting threatened butterfly species. Article 10 encourages the sustainable use of biological resources, including potential ecotourism opportunities related to butterfly watching. Article 12 emphasizes the importance of research and training, which can contribute to improved butterfly conservation strategies (CBD, 1992). Article 13 highlights the need for public education and awareness, crucial for fostering public support for butterfly conservation. Article 14 emphasizes the need to assess and minimize the impacts of human activities on butterfly habitats. Articles 17 and 18 promote the exchange of information and international cooperation (CBD, 1992), facilitating the sharing of knowledge and best practices in butterfly conservation across African countries.

The benefit of aligning these articles with butterfly conservation efforts in Africa is multifaceted. Firstly, it provides a strong legal and policy framework for integrating butterfly conservation into broader biodiversity conservation strategies. Secondly, it encourages the development of national and regional programs specifically focused on butterfly conservation. Thirdly, it facilitates international cooperation and knowledge sharing, enabling African countries to learn from each other and collaborate on effective conservation initiatives. Finally, it helps to raise public awareness about the importance of butterflies and their role in African ecosystems, fostering greater public support for conservation efforts.

African Convention on the Conservation of Nature and Natural Resources (ACCNNR)

The African Convention on the Conservation of Nature and Natural Resources (ACCNNR) offers a strong framework for butterfly conservation in Africa, even though butterflies are not its explicit focus (African Union 1968). Similar to CBD, ACCNNR promotes sustainable use of resources (Article IV) to benefit future generations, including butterflies (African Union, 1968). Healthy habitats are vital for butterflies, and ACCNNR's focus on soil and water conservation (Article V) indirectly supports their well-being (Jambhekar & Isvaran, 2016). Article VI directly encourages measures for fauna and flora conservation, potentially including specific butterfly species. Furthermore, the establishment of protected areas under Article VII provides a framework for African nations to create safe habitats for butterflies (African Union, 1968). The Convention's guidance on national biodiversity policies can lead to stronger legal frameworks for butterfly conservation at the individual country level. Finally, public awareness and local

community engagement, promoted by Article XVI, are crucial for successful butterfly conservation efforts across Africa (African Union, 1968); (Larsen, 1995).

United Nations Framework Convention on Climate Change (UNFCCC)

Climate change profoundly impacts insect biology, significantly altering their life cycles, ecology, and conservation status (Chandrakumara et al., 2023); (Moise, 2011). Rising temperatures directly influence insect development, impacting growth rates, reproduction, and population dynamics (Chandrakumara et al., 2023). Rising temperatures, altered rainfall patterns, and increased frequency of extreme weather events directly impact butterfly populations and their host plants. These changes also exert significant physiological and behavioral impacts on butterflies, leading to reduced body size, impaired flight capabilities, and decreased reproductive success (Chandrakumara et al., 2023). Different life stages of insects exhibit varying sensitivities to temperature fluctuations, influencing their overall responses to climate change (Kingsolver et al., 2011). Climate-induced shifts in distribution and phenology have been observed across numerous insect species, particularly within the order Lepidoptera (Moise, 2011). These changes can lead to range expansions, increased overwintering survival, and an increase in the number of generations per year (Chandrakumara et al., 2023). Furthermore, climate change significantly impacts intricate ecological interactions, including insect-plant relationships, predator-prey dynamics, and pheromonal communication (Chandrakumara et al., 2023). These combined effects can have cascading consequences, ultimately impacting the abundance and diversity of butterfly populations in Africa. The conservation of butterflies in Africa requires a multi-faceted approach that addresses the underlying drivers of climate change. The United Nations Framework Convention on Climate Change (UNFCCC) plays a crucial role in coordinating international efforts to mitigate climate change and its impacts. By promoting sustainable development practices, reducing greenhouse gas emissions, and enhancing climate resilience, the UNFCCC can help to protect butterfly populations and their habitats (United Nations Framework Convention on Climate Change (UNFCCC, 1992).

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) plays a crucial role in regulating international wildlife trade (Armstrong & Crawford, 1998; Naess, 2015), including butterflies, to prevent their endangerment. While currently listing only a limited number of African butterfly species, CITES provides a framework for restricting trade in threatened species, thereby reducing pressure on wild populations (Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1973). To enhance its effectiveness for butterfly conservation in Africa, several key steps are crucial: significantly expanding its coverage to include a wider range of threatened butterfly species, aligning with existing national and regional conservation strategies in Africa, actively promoting and supporting sustainable butterfly farming initiatives as an alternative to wild collection, and strengthening enforcement mechanisms to combat illegal wildlife trade and ensure compliance with CITES regulations. By implementing these measures, CITES can significantly strengthen its contribution to the conservation of butterfly diversity in Africa.

Ramsar Convention on Wetlands

The Ramsar Convention, established in 1971, is the first international treaty dedicated to wetland conservation (Ramsar Convention on Wetlands, 1971); (Davidson, 2016). While not directly focused on butterflies, it can indirectly benefit them through wetland protection. The convention promotes habitat conservation, encourages the development of management plans for wetlands, and emphasizes "wise use" practices that ensure sustainability (Ramsar Convention, 1971). Importantly, the Ramsar Convention advocates for monitoring the ecological health of wetlands, which can include tracking butterfly populations as indicators of overall ecosystem well-being (Davidson, 2016). This monitoring allows for early detection of broader environmental issues within the wetland and the implementation of corrective actions. To further align the Ramsar Convention with butterfly conservation in Africa, several key steps are crucial: explicitly recognizing butterfly species as valuable bioindicators within wetland ecosystems, highlighting their sensitivity to environmental change and their role in assessing wetland health; integrating butterfly conservation into management plans for Ramsar sites in Africa, including measures such as habitat restoration, minimizing disturbance, and promoting pollinator-friendly practices; encouraging and supporting (Ramsar Convention, 1971) research on butterfly populations within Ramsar sites in Africa, contributing to a better understanding of their ecological roles, distribution, and conservation needs; and raising public awareness about the importance of wetlands for butterfly conservation and engaging local communities in wetland protection efforts. By incorporating these measures, the Ramsar Convention can significantly enhance its contribution to the conservation of butterflies and other biodiversity within African wetlands.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, while not explicitly focused on butterfly conservation, indirectly contributes to the protection of butterfly populations in Africa (African Union, 1991). By prohibiting the illegal trade and improper disposal of hazardous wastes, such as industrial chemicals and agricultural pesticides, the Convention helps to prevent the contamination of soil and water resources, thereby safeguarding crucial butterfly habitats. Furthermore, the Basel Convention promotes the sound management and disposal of hazardous waste, minimizing pollution and environmental degradation (African Union, 1991). This reduction in pollution can have a significant positive impact on butterfly populations by mitigating their exposure to harmful substances that can adversely affect their development, reproduction, and overall survival. Ultimately, by promoting sustainable waste management practices, including waste reduction, recycling, and environmentally sound disposal methods, the Basel Convention contributes to a healthier environment, creating more favorable conditions for the survival and thriving of butterfly populations in Africa.

World Heritage Convention

The World Heritage Convention, established in 1972, fosters international cooperation to safeguard cultural and natural treasures (UNESCO, 1972). It aids developing countries with knowledge sharing, financial assistance, and coordinated efforts to combat threats like climate change and uncontrolled development (UNESCO, 1972). This ensures the preservation and transmission of these invaluable assets for future generations. The convention prioritizes natural areas with exceptional universal value, including butterfly habitats in Africa (Fleishman & Murphy 2009, Deacon & Smeets, 2013). It promotes biodiversity conservation, sustainable tourism practices, and public awareness of butterfly species. Additionally, the Convention encourages responsible land-use management to minimize negative impacts on ecosystems and butterflies (Deacon & Smeets, 2013). By recognizing these exceptional sites, the convention elevates their importance for conservation (Fleishman and Murphy, 2009); (Deacon & Smeets, 2013). Remarkably, several African World Heritage sites, like Virunga National Park (Democratic Republic of the Congo) and Bale Mountains National Park (Ethiopia), are crucial habitats for butterfly conservation.

THE BENEFITS OF ALIGNING BIODIVERSITY CONVENTIONS FOR BUTTERFLY CONSERVATION

Butterflies are sensitive indicators of environmental health, and their populations are declining globally due to habitat loss, climate change, and unsustainable practices (Gravari-Barbas & Jacquot, 2014). Africa, high biodiversity, is generally less than that found in South America and Southeast Asia (Barlow et al., 2018), is home to a stunning variety of butterfly species. However, many African butterflies face similar threats (Pomeroy, 1993). To conserve these butterflies, a coordinated approach that aligns regional and international biodiversity conventions is crucial. Below is a breakdown of how the listed conventions contribute to butterfly conservation. Firstly, conventions help habitat protection and restoration programs. Habitat loss is a major threat to butterflies, fragmenting populations, disrupting their environment, and exposing them to dangers (Steffan-Dewenter & Tscharntke, 2000); (Hanski, 2011). This includes the loss of essential food sources, inadequate shelter and breeding sites, increased exposure to predators and parasites, heightened competition for resources, and the disruptive impact on their vital migration patterns. Thus, conservation efforts focusing on protecting habitats and addressing the root causes of this loss help butterfly conservation (Dennis et al., 2006); (Pullin, 2012). International agreements promote habitat protection and restoration through creating protected areas, sustainable land management, and international cooperation. These conventions also encourage local community participation (Hanski, 2011). Biodiversity conventions enhance local community participation by recognizing the role of indigenous knowledge, promoting equitable benefit-sharing, providing capacity-building support, decentralizing decision-making, and addressing drivers of biodiversity loss like poverty. These measures empower communities to engage in conservation efforts. However, challenges such as limited data, weak enforcement, insufficient funding, lack of awareness, and inadequate climate change considerations hinder effective butterfly conservation in Africa, threatening biodiversity (Dennis et al., 2006). Second, conventions support species-specific conservation and management (SSCM) programs. SSCM adapts conservation efforts to each butterfly's needs (Chowdhury et al., 2023). It involves research on their life history, addressing specific threats, and monitoring populations (Habel et al., 2019). SSCM emphasizes efficient resource use, and public engagement, and serves as an indicator of overall ecosystem health (Thomas et al., 2010); (Chowdhury et al., 2023). International agreements further support butterfly conservation by regulating trade and promoting cooperation for migratory species (Corn, 2006). This targeted approach allows for effective interventions and maximizes the impact of conservation efforts. The SSCM offers several benefits for butterfly conservation including increased effectiveness, targeted solutions to threats like habitat loss, climate change, disease, and overcollection, adaptive management, public awareness and engagement, and serving as ecological indicators (Gillespie, 2013); (Lewandowski & Oberhauser, 2016). By focusing on specific butterfly species, SSCM ensures efficient resource use and successful interventions, while also allowing for adjustments and improvements over time (Oberthür, 2009).

Third, conventions can help research, public education, and collaboration for butterfly conservation in Africa (Von Bieberstein et al., 2019). They raise awareness and encourage collaboration through strategies, regional agreements, and support (Baakman, 2011, Nummelin and Urho, 2018). These networks connect stakeholders (Dongmo et al., 2023) and foster regional collaboration on education and conservation efforts (Baakman 2011); (Von Bieberstein et al., 2019). A three-pronged strategy is essential for effective butterfly conservation in Africa, encompassing research, education, and collaboration (Stephenson et al., 2021). Research provides the foundation for informed conservation practices, while public education fosters broader support and citizen science engagement (Ardoin et al., 2020). Collaborative efforts optimize resource allocation and maximize conservation impact (Griffin & Ali, 2014).

Fourth, conventions play a role in supporting environmental impact assessments (EIAs) and monitoring programs (Dongmo et al. 2023). Development projects pose significant threats to butterfly populations, making EIAs crucial tools for identifying and mitigating potential impacts (Morgan, 2012). EIAs involve systematic planning, impact assessment, and the development of strategies to minimize harm to butterflies (Williams & Dupuy, 2017). By fostering informed decision-making, these efforts contribute to the development of pathways that help protection of butterfly populations, especially in Africa (Fetso, 2022). Generally, biodiversity conventions can effectively contribute to butterfly conservation by promoting habitat protection, species-specific conservation, research, education, collaboration, and environmental impact assessments. A comprehensive approach integrating these elements is crucial for conservation of Africa's butterfly populations.

Table 1. International Conservation Conventions and Their Benefits to African Butterflies

Convention	Mechanism	Benefit to Butterflies
CBD (Convention on Biological Diversity)	Framework for monitoring, conservation, sustainable use, awareness, cooperation	Protects butterfly habitats, ensures legal conservation measures, raises public awareness
ACCNNR (African Convention)	Sustainable use, habitat protection, protected areas, community engagement	Preserves butterfly habitats, reduces habitat destruction, engages locals in conservation
UNFCCC (Climate Change Convention)	Addressing climate change impacts	Reduces climate threats (e.g., habitat loss, extreme weather) to butterfly populations
CITES	Regulating international trade of species	Prevents overharvesting and illegal trade of rare butterfly species
Ramsar Convention (Wetlands)	Protecting wetland ecosystems	Safeguards wetland habitats essential for butterflies Provides monitoring frameworks for species tracking Engages communities in pollinator conservation
Basel Convention	Controlling hazardous waste	Reduces pollution and toxins that harm butterflies and their habitats
World Heritage Convention (WHC)	Protecting globally significant natural sites	Ensures long-term Legal protection of critical butterfly habitats (e.g., forests, grasslands) Funding mechanisms for research/ management Global recognition that drives local action

SUCCESS STORIES OF BIODIVERSITY CONVENTIONS IN AFRICA

Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA)

KAZA TFCA, located in the Kavango and Zambezi River basins, is larger than Germany and Austria combined and nearly twice as large as the UK (Stoldt et al., 2020). It features the Okavango Delta and Victoria Falls. The Kavango -Zambezi Transfrontier Conservation Area (KAZA TFCA) is a vast transboundary protected area in southern Africa, spanning Angola, Botswana, Namibia, Zambia, and Zimbabwe (Stoldt et al., 2020). The vast KAZA TFCA offers an important safe haven for butterfly conservation. Established under the CBD and Ramsar Convention, this transboundary park protects diverse habitats, promotes butterfly movement through reduced fragmentation, and facilitates collaborative monitoring programs across member countries (UNESCO World Heritage Centre n.d.). Thus, international conventions play a pivotal role in advancing butterfly conservation. As exemplified by KAZA TFCA, these agreements facilitate large-scale conservation efforts. By fostering cooperation among nations, conventions enable the creation of expansive protected areas, such as KAZA, which provide critical habitats for diverse butterfly species. Moreover, these frameworks promote habitat connectivity, reducing fragmentation that can threaten butterfly populations. Collaborative monitoring programs, facilitated by conventions, enhance our understanding of butterfly distributions and trends, informing targeted conservation actions.

The Maloti-Drakensberg Transfrontier Conservation Area (MDTFCA)

The Maloti-Drakensberg Transfrontier Conservation Area (MDTFCA) exemplifies the success of transboundary collaboration in butterfly conservation (KZN Wildlife n.d.). Established under the CBD, this UNESCO World Heritage Site, spanning Lesotho and South Africa, safeguards a diverse mountain landscape highly important for numerous butterfly species (Zunckel, 2012). The pronounced elevation changes within MDTFCA create a range of microclimates, supporting high-altitude specialists and valley-dwelling butterflies (Gorilla Agreement n.d). Furthermore, the protected area is a vital refuge for endemic butterfly species, ensuring their long-term survival by minimizing threats like overgrazing, invasive species, and habitat degradation (Gorilla Agreement n.d). Collaborative monitoring programs facilitated by MDTFCA foster improved research and understanding of butterfly populations within this unique ecosystem.
Thus, international conventions are pivotal in fostering transboundary collaboration for butterfly conservation. The Maloti-Drakensberg Transfrontier Conservation Area (MDTFCA) serves as a prime example of this success. By spanning Lesotho and South Africa, it facilitates cross-border cooperation in conservation efforts, enabling the protection of migratory species and shared habitats. Moreover, the convention's framework supports collaborative research and monitoring initiatives, enhancing our understanding of butterfly populations and informing effective conservation strategies within this unique region. By replicating the collaborative spirit, robust legal frameworks, and strong community engagement demonstrated in these case studies, butterfly conservation initiatives across Africa can significantly benefit. While challenges persist, the successes achieved in KAZA TFCA and MDTFCA underscore the transformative power of international cooperation in safeguarding African wildlife.

CHALLENGES AND GAPS OF BIODIVERSITY CONVENTIONS FOR AFRICAN BUTTERFLY CONSERVATION

While international biodiversity conventions offer a framework for conserving butterflies in Africa, significant challenges hinder their full effectiveness (Takang, 2014, Geijzendorffer et al., 2017, Phang et al., 2020). Some of these challenges are listed in the following.

Implementation Challenges

Many African countries lack the financial and human resources for the effective implementation of convention provisions (Dirzo & Raven, 2003, Birhanu, 2010,

Botchway & Hlovor, 2019). This can hinder their ability to conduct thorough research, establish protected areas, or implement conservation programs. Thus, the most important is capacity building (Phang et al., 2020). However, building the capacity of local governments and communities to manage butterfly conservation programs effectively can be challenging. Monitoring the effectiveness of conservation efforts and enforcing regulations to protect butterflies can be difficult, especially in vast and resource-limited African landscapes (Geng et al., 2023).

Limitation of Butterfly-Specific Focus

Biodiversity conventions offer a double-edged sword for butterfly conservation in Africa. On the positive side, they indirectly protect habitats, raise awareness, integrate butterfly conservation into national plans, and provide funding. However, they often lack a species-specific focus, have limited resources, and compete for attention with other conservation priorities. While conventions encourage holistic national biodiversity strategies, there is a need for more targeted plans for critically endangered African butterflies. Translating broad goals into actions requires additional focus and resources within African nations. Furthermore, conventions lack specific action plans for individual species. To maximize effectiveness, butterfly conservation can be integrated into National Biodiversity Strategies and Action Plans (NBSAPs) (Phang et al., 2020). Raising awareness about butterflies' ecological importance and developing targeted strategies within broader plans can create a holistic approach benefiting all species.

Gaps in Addressing Specific Threats

Habitat loss and degradation in Africa, particularly to butterflies, is a major threat to biodiversity (Ayyad, 2003). Factors include land-use change, unsustainable resource extraction, climate change, and invasive species (Maitima et al., 2009). Conventions often lack enforcement mechanisms to prevent habitat loss, and climate change impacts butterfly populations as degradation disrupts breeding grounds, food plants, movement patterns, genetic diversity, and microclimate (Maitima et al., 2009); (Mohammed, 2020). Effective communication, stronger regional collaboration, and knowledge sharing between African nations, researchers, and NGOs involved in butterfly conservation can be aided hampered by logistical and financial constraints (Mabudafhasi, 2002).

Data Deficiencies on Butterflies

The conservation of African butterflies faces significant challenges due to critical data deficiencies regarding species diversity, population trends, and ecological roles (Bonebrake et al., 2010; Xing et al., 2019). Many regions remain understudied, with vast landscapes inadequately monitored due to financial and logistical constraints (Zerbe, 2005). This paucity of information creates substantial barriers to identifying priority species, assessing conservation status, and evaluating the effectiveness of protection measures (Girardello et al., 2019). Compounding these challenges is the limited understanding of butterflies' ecological functions—particularly their roles as pollinators, bioindicators, and prey within food webs—which undermines efforts to quantify their broader ecosystem value (Chakraborty, 2019).

To address these gaps, a multi-pronged approach is essential. First, targeted investments in research and long-term monitoring programs could establish baseline data on distribution, abundance, and habitat requirements (Hochkirch et al., 2020). Standardized protocols, such as those developed for citizen science initiatives, could enhance data comparability across regions (Lewandowski & Oberhauser, 2016). Second, community-led monitoring frameworks, like those successfully implemented in Central Africa (Dongmo et al., 2023), offer cost-effective and scalable solutions while fostering local stewardship. Third, integrating butterfly-specific metrics into national biodiversity policies—for example, through IUCN Red List assessments or National Biodiversity Strategies and Action Plans (NBSAPs)—could elevate their conservation priority (Habel et al., 2023). Emerging technologies, including environmental DNA (eDNA) analysis and remote sensing, could further revolutionize monitoring in remote areas (Bálint et al., 2021). Ultimately, closing these knowledge gaps is not merely an academic exercise but a prerequisite for evidence-based conservation. By combining scientific research, community engagement, and policy innovation, stakeholders can develop adaptive strategies that safeguard Africa's butterfly diversity amid escalating threats like habitat loss and climate change (Warren et al., 2021).

CONCLUSION AND FUTURE RECOMMENDATIONS

Conclusions

International biodiversity conventions form the backbone of butterfly conservation strategies in Africa. These conventions, including the Ramsar Convention, World Heritage Convention, CBD, and CITES, provide a framework for collaboration, resource sharing, and best practices They promote habitat protection, sustainable land management, and species-specific conservation plans for butterflies While some conventions like Ramsar and UNFCCC indirectly benefit butterflies through wetland and climate change mitigation efforts, others like CBD, and CITES have a more direct impact by focusing on species-specific conservation and trade regulation. The true strength lies in aligning these international frameworks with national implementation strategies. Challenges like weak enforcement and limited resources can be addressed by prioritizing butterflies in national biodiversity plans, developing targeted action plans, and investing in research and capacity building. Strengthening regional cooperation and fostering community engagement is also crucial for effective on-the-ground action. By bridging the gap between international goals and national implementation, African nations can harness the power of these conventions to secure a brighter future for their magnificent butterfly populations.

Future Recommendations

International biodiversity conventions provide a valuable foundation for safeguarding Africa's butterflies. However, to maximize their effectiveness, a multi-pronged approach is needed. First, national efforts must be strengthened by prioritizing butterflies in National Biodiversity Strategies and Action Plans (NBSAPs) with clear goals and measurable targets. Species-specific or habitat-focused action plans, aligned with international conventions, can further improve focus. Second, investing in research on butterfly diversity, distribution, and populations deliver information for effective conservation planning. Building local capacity in butterfly monitoring, identification, and habitat management empowers local communities. Strengthening

regional collaboration, particularly for shared habitats and migration corridors, facilitates joint conservation efforts, knowledge sharing, and the establishment of transboundary-protected areas. Standardized monitoring programs across different countries are crucial to addressing knowledge gaps on butterfly distribution, population sizes, and ecological needs. Finally, mainstreaming butterfly conservation into landscape management plans and promoting public awareness about their ecological importance fosters broader support for these lovely creatures. By implementing these multifaceted strategies, African nations can significantly enhance butterfly conservation efforts by leveraging the framework provided by international conventions.

AUTHOR INFORMATION

Gebreegziabher Hailay: Conceptualization (lead); methodology (lead); validation (lead); visualization (lead); writing original draft (lead); writing review and editing (lead).

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ORCID

Gebreegziabher Hailay: https://orcid.org/0009-0008-9719-9971

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