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Biodiversity's Crucial Role in Climate Change Adaptation Strategies

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ABSTRACT
Climate change greatly impacts ecosystems and, together with land-use change, is among the main drivers of biodiversity loss. In turn, biodiversity and its sustainable use can help people and communities mitigate and adapt to climate change by increasing ecosystem resilience. The high degree of interdependence requires critical consideration of the interlinkages between climate and biodiversity in policy-making. However, national-level response measures responding to these challenges have often been siloed and separated. This fragmented approach jeopardizes countries' ability to address the intertwined causes and impacts of climate change and biodiversity loss. Strengthening domestic policy coherence between effective climate change adaptation and biodiversity actions provides many opportunities to increase integration, reduce duplication, and make the best use of limited resources for planning, implementation, monitoring, and finance. This paper frames the key issues regarding biodiversity role in ecosystem-base adaptation globally and nationally. It emphasizes the need to analyze how biodiversity supports ecosystem functions that help communities adapt to climate-related risks and to understand barriers such as funding, awareness, and governance, and propose solutions. The paper makes a case for adopting biodiversity led adaptation as a sustainable approach, i.e., adaptation that is inclusive, and considers the synergies with other development agenda while also providing value for scarce resources.
Keywords: Climate change, ecosystems, biodiversity, adaptation, sustainability, adaptation strategies, living organisms, habitats, species

INTRODUCTION

Climate change is one of the all-encompassing global environmental changes likely to have deleterious effects on natural and human systems, economies and infrastructure. Manifestations such as rising temperatures intensified extreme weather events, sea-level rise, and altered precipitation patterns exacerbate environmental degradation and socio-economic instability. The risks associated with it call for a broad spectrum of policy responses and strategies at the local, regional, national and global level (Hansen et al., 2020).

Biodiversity is a variety of all forms of life. It is the variability among living organisms and their habitats, including the diversity within species, between species, and within ecosystems. Biodiversity underpins the essential goods and services that ecosystems provide, and has value for current uses, possible future uses, and intrinsic worth. There are 530 million distinct species on Earth, the most being micro-organisms. Only about 1.75 million have been formally documented (Hancock L. 2022).

All the interactions between the components that make up the total global biodiversity set the foundations on which human society has evolved. Biodiversity-based adaptive and mitigating strategies can enhance the resilience of ecosystems and reduce the risk of damage to human and natural ecosystems. Mitigation is described as a human intervention to reduce greenhouse gas sources or enhance carbon sequestration. Adaptation to climate change refers to adjustments in natural or human systems in response to climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (Shiswad, Akole 2012).

Statement of the Problem

The escalating impacts of climate change, characterized by rising global temperatures, shifting precipitation patterns, and increased frequency and severity of extreme weather events, pose profound threats to ecosystems, human societies, and economies worldwide (IPCC, 2018). The loss of biodiversity and degradation of ecosystem exacerbate vulnerability to climate impacts, compromising the reliance of natural and human systems, and understanding efforts to achieve sustainable development (WWF, 2020).

Despite its crucial role in climate regulation, food scarcity, livelihoods, and human well-being, biodiversity's contribution to climate adaptation remains undervalued, poorly understood, and inadequately integrated into policy frameworks, hindering effective conservation, sustainable development, and climate resilience (CIP, 2019). Ecosystem-based adaptation, such as mangrove restoration and sustainable forest management, offers cost-effective solutions to climate risks, yet remains underutilized (UNEP, 2020). The lack of robust evidence and policy frameworks supporting biodiversity's role in climate adaptation strategies perpetuates ecosystem degradation, increases climate

risks, and threatens the well-being of communities particularly in vulnerable regions like Nigeria (UNEP, 2020). This study examines the critical contributions of biodiversity to climate change adaptation strategies, identifying gaps, opportunities, and best practice for enhancing resilience, informing policy, and promoting sustainable development in the face of climate change.

Objectives of the Study

This study aims to investigate the role of biodiversity in climate adaptation. The primary research objectives are:

1. To examine the impact of climate change on biodiversity and biodiversity loss and climate vulnerability.
2. To investigate successful case studies on ecosystem based adaption.
3. To understand role of biodiversity in enhancing climate resilience.
4. To explore the international frameworks - integrating biodiversity into climate adaptation policies.
5. To examine the national and local strategies for implementing ecosystem-based adaptation.

Research Questions

To achieve the objectives of the study; the following research questions answered.

1. How does climate change impact on biodiversity and climate vulnerability?
2. What are the successful case studies on ecosystem-based adaption?
3. What is the role of biodiversity in enhancing climate resilience?
4. What are the international frameworks - integrating biodiversity into climate adaptation policies?
5. What are the national and local strategies for implementing ecosystem-based adaptation?

Significance

The significance of this study lies in its potential to:

1. Highlight biodiversity as a natural solution to climate challenges, offering cost-effective and sustainable adaptation options.
2. Support policy and planning efforts by providing evidence on the importance of conserving ecosystems to protect vulnerable communities.
3. Encourage ecosystem-based approaches that deliver multiple co-benefits, including improved livelihoods, food and water security, and disaster risk reduction.
4. Promote the inclusion of indigenous knowledge, which plays a vital role in sustaining biodiversity and enhancing community-based adaptation.
5. Contribute to global climate action goals, such as those outlined in the UN Sustainable Development Goals (SDGs), the Paris Agreement, and the Convention on Biological Diversity.

Scope and Limitations of the Study

Scope

This study focuses on understanding how biodiversity contributes to climate change adaptation at local, national, and global levels. It covers various ecosystems—such as forests, wetlands, coastal zones, and agricultural lands—and examines how their biodiversity supports adaptation efforts.

The research includes an overview of ecosystem-based adaptation strategies, the role of genetic and species diversity in resilience, and the integration of traditional knowledge. The scope also extends to relevant policies and practical examples across different geographic contexts.

Limitations

This study is limited by its reliance on existing literature and policy documents, without primary data collection or empirical analysis. The study's scope is restricted to reviewing and synthesizing existing knowledge, and its findings are constrained by the availability and quality of published research on biodiversity and climate adaptation in Nigeria and globally.

Literature Review

Understanding Biodiversity and Climate Change

The ever-increasing threat of climate change has far-reaching consequences for the planet's biodiversity and ecosystem, with devastating impacts on specie, ecosystem, and human societies. As climate change alters environmental conditions. It disrupts the delicate balance of the ecosystems, leading to unprecedented biodiversity loss and ecosystem degradation.

Impacts of Climate Change on Biodiversity

Climate change poses a significant threat to global biodiversity, with far-reaching consequences for ecosystem species, and human societies (IPCC, 2020). Rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events disrupt the delicate balance of ecosystems, leading to:

1. Species extinction: Climate change exacerbates species vulnerability, with estimates suggesting that 15-37% of species are at risk of extinction (Thomas et al., 2004).
2. Ecosystem disruption: Change in species distribution, population dynamics, and community composition alter ecosystem functioning and resilience (Walther et al., 2002).
3. Loss of ecosystem services: Climate-driven changes to ecosystems compromise essential services, including pollination, pest control, and nutrient cycling (MEA, 2005).

Key Impacts

Impact	Disruption	Reference
Range shifts	Change in species distribution and migration pattern	Parmesan & Yohe (2003)
Phenological changes	Altered timing of seasonal events (e.g, flowering, migration)	Root et al., (2003)
Population decline	Reduced population sizes and increased extinction risk	Saether et al., (2000)

Case studies in Nigeria

In Nigeria, climate change threatens biodiversity hotspots like the Niger Delta and tropical rainforests, with projected impacts on:

- Forest ecosystems: Changes in tree species composition and increased wildfires (Adefolalu, 2007).
- Freshwater ecosystems: Altered water flows and increased pollution (Ofoegbu et al., 2016).

Millennium Ecosystem Assessment (MEA) predicts climate change to be the principal threat to the biological diversity (Anonymous, 2007). Anonymous (2009) further reported that changes in climate affects the normal life cycle of plant. He equally pointed out that invasive species (Lantana, Parthenium and *Ageratum conyzoides*) are a threat to native species being more tolerant to climatic variations. Variation in temperature and precipitation patterns can result in more frequent droughts and droughts and floods making indigenous plants more vulnerable to pests and diseases. Slight change in climatic condition leads to the extinction of animal species. For example, climate change has resulted in extinction of animals like golden toad and Monteverde harlequin frog (McCarthy et al., 2001).

Biodiversity Loss and Climate Vulnerability

Climate change disturbs ecosystems, causing declines in biodiversity and changes in the species composition of flora and fauna. The ecosystems of marine, coastal, wetland and high mountain zones are the most sensitive to climate change. Climate change also intensifies the exposure of local species and varieties to invasive species and pests, which explore new habitats with tolerable climate conditions (Okali, D.U.U. (2004).

Biodiversity loss hampers the ability to mitigate and adapt to climate change. The loss of biodiversity for food and agriculture – including the loss of crop diversity and local varieties and lower in-field diversity – leads to a decline in the flow of ecosystem services upon which agriculture depends and undermines the

resilience of agrifood systems against climate change. Biodiversity loss reduces ecosystem functioning, negatively affecting the ability of landscapes and waters to store CO_2.

The continued degradation of land, which currently stores four times more carbon than the atmosphere, is exacerbated by climate change threats and is turning many land ecosystems into CO_2 emitters (IPCC, 2022). Climate change compromises the ability of agroecosystems and the biodiversity for food and agriculture they contain to provide the service of removing CO_2. Furthermore, biodiversity loss threatens humans' ability to adapt to rising climate challenges, inevitably weakening their resilience to climate change.

The reduction of biodiversity undermines ecosystems' ability to act as natural buffers against climate-induced extreme weather events, such as providing coastal protection from storms and rising sea levels, reducing flooding, buffering heatwaves and mitigating other risks caused by climate change (Mangelsdorf et al, 2015).

The mutually reinforcing and complex nature of climate change and biodiversity loss requires the consideration of a variety of outcomes and the application of coordinated solutions, including nature-based solutions, that deliver the highest benefits and the fewest trade-offs, effectively mainstreaming them together.

To activate and orchestrate transformative change within the climate–biodiversity nexus, policy models must be built on the solid evidence of cascading and iterative effects, must be context-specific, and must be integrated with the multi-actor governance approach (Nature, 2004).

Ecosystem-Based Adaptation (EbA)

Ecosystem-Based Adaptation (EbA) is said to be; "The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change." (CBD 2009)."Adaptation policies and measures that take into account the role of ecosystem services in reducing the vulnerability of society to climate change" (Vignola et al. 2009). "Local and landscape scale strategies that enable both people and nature to adapt in the face of climate change" (IUCN 2009).

There are six cases linking forest and tree ecosystem services to adaptation can be distinguished from the analysis:

- Forests and trees providing goods to local communities coping with climate variability;
- Trees regulating water, soil and microclimate in agricultural fields for increased resilience;
- Forests regulating water and protecting soils in watersheds for increased resilience;
- Forests protecting coastal areas from climate related threats;
- Urban forests and trees regulating temperature and water for resilient cities; and
- Forests regulating atmospheric pressure and moisture, thus influencing rainfall at the regional scale (Locatelli B and Vignola R. 2009).

EbA may provide multiple benefits in addition to adaptation, such as carbon storage, pollination services and livelihood diversification. Although it complements common approaches to natural resource and biodiversity management. EbA is distinctive because it focuses on adaptation needs and benefits and places these in the context of an overall adaptation strategy. It also positions people at the centre because it involves community-based and fully participatory approaches (Pramova E et al, 2012).

Case Studies of EbA in Practice

Case 1: Cambodia Adaptation Fund Project– Enhancing Climate Change Resilience of Rural Communities living in Protected Areas Case study compiled and edited by: C4EcoSolutions (www.c4es.co.za), October 2015 - The majority of rural Cambodians are reliant on traditional livelihood practices that include subsistence-based agriculture, fishing and other livelihoods based on ecosystem goods and services. As a result of the limited socio-economic development of Cambodia's rural areas, and the limited financial resources and technical capacity of rural communities, there are very few alternative livelihood options for these communities to adopt.

A consequence of the widespread reliance on livelihoods based on ecosystem goods and services is that Cambodia's rural population is likely to experience particularly severe negative impacts as a result of

climate change. The effects of climate change in Cambodia are anticipated to include increasingly erratic rainfall, and increased frequency and severity of climate-related hazards such as droughts and floods. The negative effects of climate change have already been experienced by rural Cambodian households, for example the reduced productivity of agriculture as a result of erratic rainfall.

To respond to this challenge, an Adaptation Fund (AF) project was developed by UNEP and Cambodia's Ministry of Environment entitled "Enhancing Climate Change Resilience of Rural Communities living in Protected Areas in Cambodia" for the period 2013-2017. This project aims to enhance the climate change resilience of communities living around five community protected area (CPA) intervention sites (as well as downstream communities) through implementation of the ecosystem-based approach to adaptation (EbA).

Case 2: Great Green Wall Initiative Case study compiled and edited by: C4EcoSolutions (www.c4es.co.za), May 2015 - The Sahel – located between the Sahara Desert to the north and the Sudan in the south – is vital for the future welfare of ~40 million people. However, poverty and food insecurity are pervasive in this region. Efforts to eradicate socio-economic challenges in the Sahel need to include strategies to manage natural resources and address the drivers of poverty. One such strategy is the Great Green Wall Initiative. This initiative improves livelihoods of rural communities by promoting sustainable agricultural development and improved land management practices.

Ecosystem-based adaptation and mitigation solutions for Farmers' Clubs in Zambezi basin, Mozambique Case study compiled by ACTS for EbA South, July 2016. - To address the nexus challenges of poverty, food insecurity, climate change and ecosystem degradation in Zambezi basin, Mozambique, this UN Environment-funded project promoted the ecosystem-based adaptation (EbA) approach of conservation agriculture (CA), with interventions such as; i) no tillage and minimum tillage farming; ii) mixed farming; iii) crop diversification and the introduction of drought resistant crops; iv) introduction of agroforestry systems; and v) reforestation of degraded areas.

Benefits and Limitations

Ecosystem-based adaptation (EbA) offers a range of benefits including increased resilience to climate change impacts, improved livelihoods, and enhanced biodiversity, but it also faces limitations like high initial costs, potential social inequalities, and the need for long-term commitment (Alexander, S., and McInnes, R. (2012).

Benefits of Ecosystem-base Adaptation:

- **Climate Change Resilience:** EbA utilizes ecosystems to mitigate the impacts of climate change, such as extreme weather events, by providing natural buffers and reducing vulnerability. For example, coastal ecosystems like mangroves can protect against storm surges and erosion (M. Ruth Martínez-Rodríguez et al 2018).
- **Livelihood Improvement:** EbA can create new economic opportunities through sustainable resource management, ecotourism, and the provision of ecosystem services like clean water and fertile soil (Philemon Dong-Uuro & Kenneth Peprah, 2023).
- **Biodiversity Conservation:** By conserving and restoring ecosystems, EbA contributes to the protection of biodiversity, which is essential for ecosystem health and resilience (CBD (2009).
- **Social Equity:** EbA can empower local communities, increase their participation in decision-making, and improve their access to resources (Devisscher, T. (2010).
- **Cost-Effectiveness:** In the long run, EbA can be a cost-effective adaptation strategy compared to some conventional, infrastructure-based approaches (Boardman A.E. et al, 2006).

Limitations of Ecosystem-base Adaptation:

- **High Initial Costs:** Establishing and maintaining ecosystems for adaptation can require significant upfront investment in resources and expertise (Pangilinan M.J.M., et al 2015).
- **Potential for Social Inequalities:** If not implemented carefully, EbA projects can exacerbate existing social inequalities, potentially favoring certain groups over others in terms of access to resources and benefits (Kumar K.K.S., et al 2010).

- **Long-Term Commitment:** EbA requires sustained commitment and monitoring to ensure the long-term effectiveness of ecosystem restoration and management (Pramova E et al, 2012).
- **Uncertainty and Complexity:** Ecosystems are complex and dynamic, and predicting the precise impacts of climate change on specific ecosystems can be challenging (PeñalbaL.M., ElazeguiD.D. (2011).
- **Integration with Other Sectors:** EbA may require coordination and integration with other sectors, such as agriculture, water management, and disaster risk reduction, which can pose challenges (TEEB, 2009).
- **Lack of Awareness and Capacity:** In some cases, there may be a lack of awareness and capacity among stakeholders regarding the potential benefits and implementation of EbA practices (TEEB, 2009).

Role of Biodiversity in Enhancing Climate Resilience

Natural Buffers and Disaster Risk Reduction

Biodiversity plays a crucial role in enhancing climate resilience by acting as natural buffers and contributing to disaster risk reduction. Diverse ecosystems are more adaptable to climate change impacts, offering various benefits like carbon sequestration, coastal protection, and water regulation, which help mitigate the effects of extreme weather events (World Bank, 2021).

How Biodiversity Enhances Climate Resilience

1.Natural Buffers: Intact ecosystems like forests, wetlands, and coastal zones act as natural buffers against climate-related hazards. They can absorb storm surges, reduce erosion, and mitigate the impact of floods and droughts (Giacomo Fedele et al, 2016).

2. Disaster Risk Reduction: Healthy ecosystems reduce vulnerability to disasters by providing vital services like water purification, food production, and climate regulation. For example, mangrove forests protect coastlines from erosion and storm surges, while forests help regulate water flow and reduce flood risks (Policy Brief: Nature for Resilience – UNDRR 2024).

3. Adaptation to Climate Change: Species-rich and genetically diverse ecosystems are more resilient to climate change impacts. They are better able to adapt to changing environmental conditions, such as increased temperatures and altered precipitation patterns (Richard Munang et al, 2013).

4. Ecosystem-based Disaster Risk Reduction (Eco-DRR): This approach utilizes ecosystems and biodiversity to reduce disaster risks and enhance climate resilience. It involves integrating biodiversity conservation and sustainable ecosystem management into disaster risk reduction strategies such as sustainable management, community involvement in preserving ecosystems (Afful-Koomson, T. 2015).

Soil Health, Water Regulation, and Food Security

Biodiversity plays a crucial role in enhancing climate resilience by supporting healthy ecosystems that provide essential services for soil health, water regulation, and food security. Diverse ecosystems are more resilient to climate change impacts, offering a buffer against extreme weather events and promoting sustainable food production (Sharma, A. 2022).

Here's how biodiversity contributes to climate resilience:

1. Soil Health:

- **Nutrient Cycling:** A wide array of soil organisms (bacteria, fungi, earthworms, etc.) are involved in breaking down organic matter and releasing essential nutrients for plant growth. This process, known as nutrient cycling, is crucial for maintaining soil fertility and reducing the need for synthetic fertilizers (WEF. (2013).
- **Water Infiltration and Retention:** Diverse plant communities with varying root structures improve soil structure and water infiltration, reducing runoff and erosion, and enhancing water retention in the soil. This helps to mitigate the impacts of drought and flooding (World Bank, 2013).

- **Carbon Sequestration:** Healthy soils rich in organic matter, a result of biodiversity, play a vital role in storing carbon, helping to mitigate climate change by reducing atmospheric carbon dioxide levels (World Bank, 2013).

2. Water Regulation:

- **Water Purification:** Diverse plant and microbial communities in ecosystems filter and purify water, reducing pollution and improving water quality (TNC, 2009).
- **Water Storage and Flow:** Intact ecosystems with a variety of plant and animal species help regulate water flow, preventing excessive runoff during heavy rainfall and maintaining water availability during dry periods (World Bank, 2013).
- **Reduced Erosion:** Healthy vegetation cover, promoted by biodiversity, helps to prevent soil erosion, which can lead to sedimentation of waterways and loss of fertile land (TNC, 2009).

3. Food Security:

- **Increased Crop Yields:** Diverse cropping systems, including intercropping and crop rotations, can enhance yields by improving soil fertility, reducing pest and disease outbreaks, and increasing pollination ((Sharma, A. 2022).
- **Pest and Disease Control:** Natural predators and parasites, part of a diverse ecosystem, can help control pests and diseases, reducing the need for harmful pesticides (Afful-Koomson, T. 2015).
- **Nutrient-Rich Diets:** Biodiversity supports the production of a wider variety of crops and livestock, providing access to diverse and nutrient-rich diets (Pramova E et al, 2012).
- **Adaptation to Climate Change:** Diverse agricultural systems with a range of crop varieties can better adapt to changing climate conditions, such as increased temperatures or altered rainfall patterns (Boardman A.E. et al, 2006).
- **Reduced Dependence on External Inputs:** Biodiversity-friendly agricultural practices, like organic farming and agroforestry, reduce reliance on synthetic fertilizers and pesticides, promoting sustainable and resilient food production (Pramova E et al, 2012).

International Frameworks - Integrating Biodiversity into Climate Adaptation Policies

There is growing recognition that the global climate and biodiversity crises are interlinked. Climate change has impacts on ecosystems and, together with land-use change, is among the main drivers of biodiversity loss. Without resolving the climate crisis, restoring biodiversity will not be possible.

Furthermore, actions and policies that aim to mitigate climate change and adapt to its effects can have negative impacts on biodiversity. In turn, biodiversity conservation and its sustainable use can help mitigate climate change by enhancing ecosystems' capacity for carbon capture and storage and help adapt to it through increasing ecosystem resilience.

The high degree of interdependence within living systems causes complex interplays at both the ecosystem and policy-making levels. This means that policy action (or lack thereof) to address climate change has impacts on biodiversity and vice versa. These linkages are showcased in recent major global assessments by the Intergovernmental Panel on Climate Change and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

International Agreements and Conventions Supporting EbA:

1. Convention on Biological Diversity (CBD): The CBD recognizes the importance of ecosystems and biodiversity for adaptation and sustainable development (CBD 2009).
2. UN Convention to Combat Desertification (UNCCD): The UNCCD promotes EbA as a way to address land degradation and climate change impacts in arid and semi-arid regions (UNCCD 2024).
3. Ramsar Convention on Wetlands: The Ramsar Convention highlights the role of wetlands in providing ecosystem services and supporting adaptation to climate change (Ramsar, Iran 1971).
4. UN Declaration on the Rights of Indigenous Peoples: This declaration recognizes the traditional knowledge and practices of indigenous peoples in managing ecosystems and adapting to climate change (UNDRIP, 2007).

Key aspects of the international framework for EbA:

- Integration with existing frameworks: EbA is designed to be integrated with broader adaptation and development strategies, promoting policy coherence with national and international commitments.
- Focus on ecosystem services: EbA recognizes the vital role of ecosystems in providing services like water, food, and protection from extreme weather events, and aims to maintain or enhance these services.
- Community-based approach**:** EbA often involves community participation in decision-making, recognizing the importance of local knowledge and ownership in implementing adaptation measures.
- Multiple benefits: EbA can offer multiple benefits, including biodiversity conservation, disaster risk reduction, and improved livelihoods, making it a cost-effective and sustainable approach.
- Emphasis on resilience: EbA aims to build resilience of both ecosystems and human communities to climate change impacts by strengthening ecosystem functions and reducing vulnerability(CBD,2009).

National and Local Strategies for Implementing Ecosystem-Based Adaptation

National and local strategies for implementing ecosystem-based adaptation (EbA) involve integrating ecosystem conservation, restoration, and sustainable management into broader climate change adaptation plans. These strategies aim to harness the benefits of healthy ecosystems to reduce the impacts of climate change on communities and biodiversity. Key aspects include maintaining and restoring ecosystems like wetlands, forests, and coastal areas, while also promoting integrated water resource management and coastal zone management (FGN, 2011).

National Strategies:

1. Integrating EbA into National Adaptation Plans (NAPs)**:** Many countries are incorporating EbA into their NAPs, recognizing the role of ecosystems in building resilience to climate change impacts (FGN, 2011).
2. Developing National EbA Strategies: Some countries are developing specific strategies focused on EbA, outlining goals, targets, and actions for implementing EbA across different sectors and regions (Woodley, E. 2011).
3. Strengthening Institutional Frameworks: National strategies may involve strengthening institutional capacity, coordinating across different government agencies, and establishing clear roles and responsibilities for EbA implementation (GIZ. 2019).
4. Promoting Research and Knowledge: National strategies often include investments in research to better understand the effectiveness of EbA measures and to develop innovative approaches (Woodley, E. 2011).
5. Securing Financial Resources: National governments may allocate funds for EbA projects, mobilize international climate finance, and create enabling environments for private sector investment in EbA (Great Green Wall, 2022).

Local Strategies

1. Ecosystem Restoration and Management: Local communities may engage in activities like planting trees, restoring mangroves, or improving water management practices to enhance ecosystem services (Global Centre on Adaptation, and Sharma, A. 2022).
2. Promoting Sustainable Livelihoods**:** Local strategies may integrate EbA with livelihood development, supporting communities to adapt to climate change while also improving their well-being (Global Centre on Adaptation, and Sharma, A. 2022).
3. Local Governance and Planning: Local governments play a crucial role in implementing EbA, integrating EbA considerations into land-use planning, infrastructure development, and other relevant policies (UNFCCC, 2011).

4. Ecosystem-Based Disaster Risk Reduction: Local strategies may focus on using ecosystems to reduce the impacts of extreme weather events, such as floods, droughts, and landslides (CBD, 2009).
5. Community-Based Adaptation: Local strategies often emphasize community participation and ownership in EbA initiatives, recognizing the traditional knowledge of local communities and indigenous peoples (Great Green Wall, 2022).

Challenges in Implementation

Implementing international frameworks for Ecosystem-based Adaptation (EbA) faces challenges including inadequate financing, knowledge gaps, and institutional constraints, particularly in developing countries. Other significant hurdles include the complexity of EbA, limited understanding of climate risk, and the need for effective monitoring and evaluation frameworks (Rizvi A.R., 2015).

Financial Constraints:

- ✓ EbA projects often require significant upfront investment, and securing adequate and sustained funding, especially from international sources and this can be difficult.
- ✓ There's a need to mobilize more resources for EbA and ensure that investments are effectively targeted to address adaptation needs (Venton C.C., 2010).

Knowledge Gaps and Capacity:

- ✓ A lack of comprehensive data and understanding of how ecosystems respond to climate change and how they can be effectively managed for adaptation is a major barrier.
- ✓ There's a need to improve knowledge sharing and build capacity at all levels, from local communities to policymakers, to effectively implement EbA (TNC, 2009).

Institutional and Governance Challenges:

- ✓ Existing institutional frameworks and governance structures may not be adequately equipped to support EbA, requiring policy and institutional reforms.
- ✓ Lack of coordination between different sectors and levels of government can hinder the integration of EbA into national adaptation plans and policies (Richard Munang et al, 2013).

Monitoring and Evaluation:

- ✓ Establishing robust monitoring and evaluation frameworks to assess the effectiveness of EbA interventions is crucial but can be challenging.
- ✓ There's a need to develop clear indicators and methodologies to track the impact of EbA on both ecosystems and human well-being (Venton C.C., 2010).

Social and Cultural Factors:

- ✓ Social and cultural norms, as well as local knowledge, can influence the acceptance and success of EbA interventions.
- ✓ Engaging local communities and ensuring their participation in the design and implementation of EbA projects is essential for long-term sustainability (Alexander, S., and McInnes, R. 2012).

Complexity and Trade-offs:

- ✓ EbA involves complex interactions between ecosystems, climate change, and human activities, making it challenging to predict outcomes and manage trade-offs.
- ✓ In some cases, EbA measures may compete with other development priorities or ecosystem services, requiring careful consideration of potential trade-offs (Anonymous 2007).

Summary of the Findings

The study found out that:

1. Climate change impacts negatively on the biodiversity resulting to species extinction, ecosystem disruption, and loss of ecosystem services. While biodiversity loss hampers the ability to mitigate and adapt to climate change.
2. Conversely, the case study of Cambodia Adaptation Fund (AF) project aims to enhance the climate change resilience of communities living around five community protected area (CPA) intervention sites (as well as downstream communities) through implementation of the ecosystem-based approach to

adaptation (EbA). While the Great Green Wall Initiative aims to improve livelihoods of rural communities by promoting sustainable agricultural development and improved land management practices.

3. The study with respect to research question three found out that biodiversity plays a crucial role in enhancing climate resilience by acting as natural buffers and contributing to disaster risk reduction.

4. Similarly, the study in respect of research question four established that international framework such as the Convention on Biological Diversity (CBD) recognizes the importance of ecosystems and biodiversity for adaptation and sustainable development (CBD 2009). In the same token, the Ramsar Convention highlights the role of wetlands in providing ecosystem services and supporting adaptation to climate change (Ramsar, Iran 1971).

5. The study observed that incorporating EbA into their National Adaptation Plans, recognizes the role of ecosystems in building resilience to climate change impacts (FGN, 2011). While on the local level, local strategies may integrate EbA with livelihood development, supporting communities to adapt to climate change while also improving their well-being (Global Centre on Adaptation, and Sharma, A. 2022).

CONCLUSION

Ecosystem-based adaptation (EbA) leverages the capacity of ecosystems to help people adapt to the impacts of climate change. Biodiversity plays a vital role in this process by providing essential services and enhancing the resilience of ecosystems to climate change impacts. Conserving and sustainably using biodiversity is not only important for ecological reasons but also for ensuring the long-term well-being of human societies.

RECOMMENDATIONS:

1. Strengthen Policy and Governance: Integrate EbA principles into national and local climate ecosystem change adaptation policies and plans. Establish clear guidelines and frameworks for EbA implementation, ensuring it is incorporated into relevant sectors like agriculture, water management, and disaster risk reduction.

2. Enhance Scientific Understanding: Invest in research to better understand the complex interactions between biodiversity, ecosystems, and climate change. Develop robust monitoring and evaluation systems to assess the effectiveness of EbA interventions and inform adaptive management.

3. Promote Community Participation: Involve local communities and indigenous peoples in the design and implementation of EbA initiatives. Recognize and value traditional ecological knowledge, ensuring that EbA approaches are culturally appropriate and socially equitable.

4. Address Socioeconomic Inequalities: Ensure that EbA initiatives benefit the most vulnerable populations, including those who rely heavily on natural resources for their livelihoods. Consider the potential social and economic impacts of EbA interventions, particularly on marginalized communities.

5. Foster Collaboration: Encourage collaboration and knowledge exchange between scientists, policymakers, practitioners, and local communities. Promote partnerships between different sectors and organizations to ensure a coordinated and integrated approach to EbA.

6. Secure Funding: Mobilize financial resources for EbA, recognizing its importance for both biodiversity conservation and climate change adaptation. Explore innovative financing mechanisms, such as payments for ecosystem services, to incentivize the sustainable management of ecosystems.

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