

Adapting Together, Thriving Tomorrow



Climate Change Adaptation Action Plan for the Biodiversity and Ecosystems Sector in Ghana

Enhancing Multi-Sector Planning and
Capacity for Effective Adaptation in Ghana



Contacts Information

No. 91 Starlet Street, Opp

Telephone: 050 6694760 /

050 6699466

P.O. Box M.326

info@epa.gov.gh

www.epa.gov.gh

Document Information

Title: Climate Change Adaptation Action Plan for the Biodiversity and Ecosystems Sector in Ghana: Enhancing Multi-Sector Planning and Capacity for Effective Adaptation in Ghana

Prepared for: Government of Ghana with support from GCF and UNEP





This symbol represents Biodiversity and Ecosystems Sector in the NAP Logo that represents the Biodiversity and Ecosystems Plan.



Table of Contents

ABBREVIATIONS	13
EXECUTIVE SUMMARY	15
CHAPTER 1: INTRODUCTION	17
1.1. Context	17
1.2. Aim and Objectives	18
1.3. Justification for Assessing Ghana's Biodiversity and Ecosystems Sector	19
1.4. Gendered-Responsive Action Plan for the Biodiversity and Ecosystem Sector	20
1.5. Purpose of the Biodiversity and Ecosystem Sector Action Plan	20
CHAPTER 2: METHODOLOGICAL APPROACH	22
2.1. Data Sources	22
2.2. Analytical Approach	23
2.2.1. Desk Review	23
2.2.2. Information Synthesis	24
2.2.3. Stakeholder Engagement and Consultation	24
2.2.4. Revision and Final Validation	24
2.3. Methodology	24
2.3.1. Biodiversity and Ecosystems Risk Assessment	24
2.3.2. Identification and Compilation of Sector-Specific Adaptation Actions	26



CHAPTER 3: CURRENT STATE OF BIODIVERSITY AND ECOSYSTEMS IN GHANA	29
3.1. Background	29
3.2. Overview of Biodiversity and Ecosystems Sector in Ghana	29
3.2.1. Forests	30
3.2.1.1 Wet Evergreen (Rainforest)	30
3.2.1.2 Moist Evergreen (Dry and Thicket Forest)	30
3.2.1.3 Moist Deciduous (Northwest and Southeast Types) Forest	30
3.2.1.4 Dry Semi-Deciduous Forest and Savannah	31
3.2.1.5 Swamp Forests and Mangroves	31
3.2.2. Wetland Ecosystems	32
3.2.2.1 Ramsar Sites	32
3.2.2.2 Inland Wetlands	33
3.2.2.3 Coastal Wetlands	33
3.2.3. Marine Ecosystems	34
3.2.4. Aquatic Ecosystems	35
3.2.4.1 Rivers and Lakes	35
3.2.4.2 Artificial Reservoirs	36
3.3. Trends and Patterns of Biodiversity and Ecosystems	36
3.3.1. Forests	36



3.3.2. Wetland Ecosystems	38
3.3.3. Marine Ecosystems	39
3.3.4. Aquatic Ecosystems	41

CHAPTER 4: NATIONAL CLIMATE CHANGE TRENDS **43**

4.1. Country Overview	43
4.1.1. Geographic Location	43
4.1.2. Country Profile	43
4.1.3. Demographic Characteristics	44
4.1.4. Key Economic Sectors	44
4.2. Climate Trends and Variability in Ghana	45
4.3. Projected Climate Trends	46
4.3.1. Temperature Projections	47
4.3.2. Rainfall Projections	48
4.3.3. Sea Level Rise	48

CHAPTER 5: CLIMATE CHANGE IMPACTS AND VULNERABILITY ANALYSIS OF THE BIODIVERSITY AND ECOSYSTEM SECTOR **49**

5.1. Introduction	49
5.2. Effects of Climate Change on Forest Ecosystems	49
5.2.1. Temperature-Related Risks	49
5.2.2. Rainfall Variability and Decline	49
5.2.3. Extreme Weather Events	50



5.2.4.	Deforestation and Illegal Mining (Galamsey)	50
5.2.5.	Fragmentation and Agricultural Expansion	50
5.3.	Effects of Wetland Ecosystems	51
5.3.1.	Rising Temperatures	52
5.3.2.	Erratic Rainfall Patterns	52
5.3.3.	Flooding	52
5.3.4.	Sea Level Rise	52
5.3.5.	Deforestation and Land Conversion	52
5.3.6.	5.3.6 Pollution	52
5.4.	Effects of Climate Change Risks on Marine Ecosystems	53
5.4.1.	Rising Sea-Surface Temperatures	53
5.4.2.	Sea Level Rise	53
5.4.3.	Overfishing and Habitat Degradation	54
5.4.4.	Pollution	54
5.4.5.	Ocean Acidification	54
5.4.6.	Storm Surges and Extreme Weather Events	54
5.5.	Effects of Climate Change Risks on Aquatic Ecosystems	55
5.5.1.	Rising Temperatures	55
5.5.2.	Erratic Rainfall Patterns	55



5.5.3. Flooding	55
5.5.4. Drought	55
5.5.5. Pollution	55
5.5.6. Erosion and Sedimentation	55

CHAPTER 6: PROPOSED ADAPTATION ACTIONS FOR THE BIODIVERSITY AND ECOSYSTEM SECTOR **57**

6.1. Introduction	57
6.2. Restoration and Conservation of Forest Ecosystems	57
6.3. Protection and Management of Wetland Ecosystems	58
6.4. Sustainable Management of Marine Ecosystems	59
6.5. Conservation of Aquatic Ecosystems	60

CHAPTER 7: ACTION PLAN FOR THE BIODIVERSITY AND ECOSYSTEM SECTOR **62**

7.1. Introduction	62
7.2. Adaptation Action for the Forestry Sector	62
7.3. Adaptation Action for the Wetland Ecosystem	68
7.4. Adaptation Action for the Marine Ecosystem	73
7.5. Adaptation Action for the Aquatic Ecosystem	79

CHAPTER 8: POLICY AND INSTITUTIONAL FRAMEWORK FOR THE BIODIVERSITY AND ECOSYSTEM SECTOR **83**

8.1. Introduction	83
8.2. Policy Framework for Biodiversity and Ecosystem Sector	83
8.3. Institutional Arrangements for the Implementation of the Sectoral Plan	86



8.4.	Gender Considerations for the Biodiversity and Ecosystem Sector	89
8.4.1.	Gendered Roles in Ecosystem Use	89
8.4.2.	Key Vulnerabilities of Women	89
8.4.3.	Barriers to Gender Equality in Biodiversity Management	89
8.4.4.	Institutions and Organizations Supporting Gender and Biodiversity	90
8.4.5.	Gender-Sensitive Adaptation Actions	90
8.4.6.	Examples of Gender-Responsive Initiatives	90
8.5.	Funding Arrangements for the Sector Plan	91
8.5.1.	Funding Sources and Mechanisms	91
8.5.2.	Monitoring and Reporting	92
8.6.	Anticipated Implemented Challenges and Proposed Solutions	92
8.6.1.	Inadequate Financial and Logistical Resources	92
8.6.2.	Human Resource and Capacity Deficits	93
8.6.3.	Weak Political Commitment	93
8.6.4.	Institutional Fragmentation and Coordination Issues	93
8.7.	Framework for Adaptation, Monitoring and Evaluation	94
CHAPTER 9:	CONCLUSION AND THE WAY FORWARD	96
9.1.	Summary	96
9.2.	Way Forward	96
REFERENCES		99



List of Tables

Table 1. Methodology to Identify Adaptation Options	33
Table 2. Criteria for Evaluating Adaptation Options in the Biodiversity and Ecosystem Sector	33
Table 3. Ranking of Adaptation Options	34
Table 4: Biodiversity found in each forest typology in Ghana	38
Table 5: Biodiversity in Wetland Ecosystems in Ghana	40
Table 6: Biodiversity in Marine Ecosystems in Ghana	41
Table 7. Biodiversity in Aquatic Ecosystems in Ghana	42
Table 8. Key Forest Types in Ghana: Regional Distribution, Species, and Challenges	44
Table 9. Key Wetland Types in Ghana: Notable Sites, Species, and Challenges	45
Table 10. Key marine ecosystems, notable species and issues	46
Table 11. Key Aquatic Ecosystems in Ghana: Locations, Biodiversity, and Environmental Challenges	47
Table 12. Risks and Vulnerabilities Impacting Forest Ecosystems: Biodiversity and Community Examples from Ghana	57
Table 13. Risks and Vulnerabilities Impacting Wetland Ecosystems: Biodiversity and Community Examples from Ghana	59
Table 14. Risks, Vulnerabilities, and Impacts on Marine Ecosystems	60
Table 15. Risks, Vulnerabilities, and Impacts on Aquatic Ecosystems	62
Table 16. Tall list of adaptation actions for the Forests Ecosystem	63
Table 17: Tall list of adaptation actions for Wetland Ecosystem	64
Table 18: Tall list of adaptation actions for Marine Ecosystem	66
Table 19. Tall list of adaptation actions for Aquatic Ecosystem	67
Table 20. Adaptation Actions for Forestry sub-sector	70
Table 21. Adaptation Actions for Wetland Ecosystems	75



Table 22. Marine Ecosystem Adaptation Action Plan	80
Table 23. Adaptation Action Plan for the Aquatic Ecosystem	86
Table 24. Policy Framework for Biodiversity and Ecosystem Sector in Ghana	90
Table 25. Institutional Arrangements for the Biodiversity and Ecosystem Sector Plan	92
Table 26. Summary of funding arrangements and examples	98
Table 27. Summary of challenges and proposed solutions	100



List of Figures

Figure 1: Data Sources for Biodiversity and Ecosystem Sector Assessment	29
Figure 2. Overall work approach for the Climate Change Risk Assessment for the Biodiversity and Ecosystem Sector	29
Figure 3. Methodology for Climate Change Risk Assessment (CCRA) in Biodiversity and Ecosystem Sector	31
Figure 4. Forest–vegetation belts. Image of the forest features/layers, regions.	36
Figure 5. Map of Ghana showing the five demarcated coastal wetlands (Ramsar sites) under the CWMP. Source: Dovie, 2003	39
Figure 6. Forest reserves in Ghana Source: Narh, 2024	43
Figure 7. Location of Ghana Source: World Atlas, 2024	50
Figure 8: Average mean surface air temperature annual trends with the significance of trend per decade; 1951 – 2023; Ghana	52
Figure 9: Precipitation annual trends with the significance of trend per decade; 1951 – 2023; Ghana Source: The World Bank Group (2024)	52
Figure 10: Projected departure from the natural variability of average mean surface air temperature with trends; Ghana	53
Figure 11: Projected departure from the natural variability of precipitation with trends; Ghana Source: The World Bank Group (2024)	54



ABBREVIATIONS

Abbreviation	Full Meaning
ADCOM	Adaptation Communication
CBD	Convention on Biological Diversity
CBO	Community-Based Organization
CSO	Civil Society Organization
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
FASDEP	Food and Agriculture Sector Development Policy
GCF	Green Climate Fund
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Corporation for International Cooperation)
GMet	Ghana Meteorological Agency
GoG	Government of Ghana
IUCN	International Union for Conservation of Nature
M&E	Monitoring and Evaluation
MEL	Monitoring, Evaluation, and Learning
MESTI	Ministry of Environment, Science, Technology, and Innovation
MLGRD	Ministry of Local Government and Rural Development
MLNR	Ministry of Lands and Natural Resources



MoF	Ministry of Finance
MoGCSP	Ministry of Gender, Children, and Social Protection
MoFA	Ministry of Food and Agriculture
MoFAD	Ministry of Fisheries and Aquaculture Development
MWRS	Ministry of Water Resources and Sanitation
NAP	National Adaptation Plan
NCCP	National Climate Change Policy
NDC	Nationally Determined Contribution
NDPC	National Development Planning Commission
NGO	Non-Governmental Organization
PPP	Public-Private Partnership
SDG	Sustainable Development Goal
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WRC	Water Resources Commission





EXECUTIVE SUMMARY

The Climate Change Adaptation Action Plan for the Biodiversity and Ecosystems Sector in Ghana presents a comprehensive framework for addressing the growing threats of climate change on the country's diverse ecosystems. These ecosystems—ranging from forests and wetlands to marine and aquatic habitats—play crucial roles in maintaining ecological stability, supporting livelihoods, and conserving biodiversity. However, they are under severe threat due to both climate-related and anthropogenic pressures. This plan outlines strategic interventions to enhance resilience, reduce vulnerabilities, and promote sustainable management of biodiversity and ecosystems while aligning with Ghana's commitments under international frameworks like the Paris Agreement and the Convention on Biological Diversity (CBD).

Key Findings

Ghana's ecosystems are highly vulnerable to climate change and other pressures, with each ecosystem type facing unique challenges. Forest ecosystems, which cover significant portions of Ghana, are under threat from widespread deforestation, illegal logging, and galamsey (illegal mining). These activities not only degrade critical habitats for species like forest elephants and pygmy hippopotamuses but also increase carbon emissions and reduce the ecosystem's ability to sequester carbon. Agricultural expansion, particularly in regions like Ashanti and Bono East, has led to the fragmentation of forests, further reducing biodiversity and disrupting ecosystem services.

Wetlands in Ghana, including Ramsar sites such as Keta Lagoon and Sakumo Lagoon, face significant degradation due to urban encroachment, pollution, and altered hydrological patterns. Rising temperatures and erratic rainfall patterns accelerate wetland drying and disrupt seasonal flooding, which is critical for the survival of species like tilapia and flamingos. Coastal wetlands, particularly mangrove ecosystems in areas like the Densu Delta, are being degraded by

overharvesting and sea-level rise, which undermine their role as natural buffers against storm surges and saltwater intrusion.

Marine ecosystems face severe stress from overfishing, illegal, unreported, and unregulated (IUU) fishing practices, and habitat destruction caused by coastal development. These pressures threaten key species such as groupers and snappers, reducing fish stocks that are vital for the livelihoods of coastal communities. Additionally, pollution from land-based activities, including plastic waste and chemical runoff, further degrades marine habitats, making them less productive and more vulnerable to climate impacts.

Aquatic ecosystems, including rivers like the Volta and Tano and lakes such as Lake Bosomtwe, are grappling with pollution, invasive species, and sedimentation. These challenges compromise water quality and threaten the survival of endemic species like Tilapia busumana and African catfish. Artificial reservoirs such as the Bui and Weija dams face sedimentation issues that reduce their capacity and functionality, impacting both biodiversity and human livelihoods.

The findings also highlight the disproportionate impacts of ecosystem degradation on women and marginalized groups. Women, who are often the primary resource users in many rural areas, face increased challenges as biodiversity loss reduces access to forest products, clean water, and fishing grounds. Their role in ecosystem management is crucial for achieving equitable and sustainable outcomes, yet they often lack access to resources, decision-making platforms, and gender-responsive policies.

Implementation Challenges

The effective implementation of this action plan faces several obstacles. Financial constraints are a significant challenge, as the adaptation measures outlined require substantial investment that exceeds the current capacity of many sector ministries and agencies. Overreliance on donor



funding also creates vulnerabilities, as delays in disbursements can stall critical interventions. Logistical issues, such as inadequate infrastructure and equipment for monitoring and enforcement, further exacerbate implementation difficulties.

Another major challenge is the limited capacity of institutions at regional and district levels. Technical expertise and human resource shortages hinder the ability to carry out vulnerability assessments, implement adaptation actions, and engage with local communities effectively. This is compounded by weak institutional coordination, with overlapping mandates and poor communication between government agencies leading to inefficiencies and duplication of efforts. The lack of a harmonized framework for biodiversity management further reduces the overall effectiveness of interventions.

Additionally, existing policies and legal frameworks, while robust in some areas, are not sufficiently integrated across sectors. For example, urban planning and infrastructure development often fail to incorporate biodiversity considerations, leading to habitat destruction and further ecosystem degradation. Gender considerations, although acknowledged in policy documents, are not consistently mainstreamed into implementation, leaving women and marginalized groups at a disadvantage.

Recommendations

To overcome these challenges and ensure the success of the plan, it is recommended that institutional frameworks be strengthened to clarify roles, enhance coordination, and promote accountability among implementing agencies. Financing mechanisms must be diversified to include domestic resources, private sector investments, and innovative solutions like green bonds and public-private partnerships. Local communities should be engaged as active participants in conservation and adaptation efforts, with resources and training provided to empower them to take ownership of these initiatives.



Gender-responsive approaches must be embedded in all adaptation actions to address the unique vulnerabilities of women and marginalized groups. This includes collecting sex-disaggregated data, promoting equal access to resources, and ensuring representation in decision-making processes. The adoption of modern technologies, such as Geographic Information Systems (GIS) and remote sensing, can enhance monitoring and data collection, enabling evidence-based decision-making.

Finally, a robust monitoring, evaluation, and learning framework should be developed to track progress, assess impacts, and inform adaptive management strategies. Regular reporting and stakeholder feedback will enhance transparency and accountability, building confidence among funders and other partners. By addressing these challenges and implementing the recommended strategies, Ghana can build resilient ecosystems that support biodiversity, livelihoods, and sustainable development.



CHAPTER 1: INTRODUCTION

1.1. Context

Climate change poses significant threats to biodiversity and ecosystems globally, with impacts disproportionately affecting developing countries such as Ghana (IPBES, 2019; Malhi et al., 2023). As a signatory to international frameworks like the Paris Agreement and the Convention on Biological Diversity (CBD), Ghana has committed to protecting its rich biodiversity and promoting sustainable ecosystem management in the face of climate change. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (2023) highlights that warming in West Africa is projected to exceed global averages, resulting in habitat shifts, species range contractions, and increased ecosystem vulnerability (IPCC, 2023).

In Ghana, climate change manifests through rising temperatures, erratic rainfall patterns, and more frequent extreme weather events such as droughts and floods (Asante et al., 2014). The country's fourth National Communication to the United Nations Framework Convention on Climate Change (UNFCCC, 2020) highlights the significant impact of these changes on biodiversity and ecosystems, which are critical for sustaining livelihoods and driving economic growth. Projections by the Environmental Protection Agency (2020) indicate that Ghana's mean temperature will rise by 1-3°C by 2060 and 1.5°C to 5.2°C by the 2090s, coupled with increasing rainfall variability and unpredictability.

Ghana's ecological landscape is a mosaic of dense forests, coastal savannas, inland wetlands, and varied marine ecosystems (Ampim et al., 2023; Ocloo et al., 2024). These ecosystems provide essential environmental services and support diverse biological communities, serving as foundational pillars for the nation's economy, health, and cultural heritage. Key sectors such as agriculture, forestry, and fisheries, which depend on these ecosystems, are vital for livelihoods and

economic stability. The preservation and sustainable management of these ecosystems are paramount for Ghana's development.

The country's biodiversity is significant. Forests in the Western Region, for instance, harbor over 800 higher plant species and numerous animal species, including endangered primates (Hackman, 2014; Osei et al., 2018). Coastal wetlands, such as the Muni-Pomadze Ramsar site, are critical for sustaining fish populations that support local economies. These ecosystems also act as natural buffers against disasters, mitigate flooding impacts, and filter and store water, ensuring the maintenance of hydrological cycles crucial for agriculture and human consumption.

Ghana's biodiversity also underpins food security, providing genetic materials essential for agricultural innovation and resilience. Plants and animals contribute to ecological services like pollination, soil fertility, and pest control. Moreover, they are integral to both traditional medicine and modern pharmaceuticals, derived from Ghana's flora and fauna. However, the stability of these ecosystems is increasingly threatened by climate change, manifesting through rising temperatures, changing precipitation patterns, sea-level rise, and more frequent extreme weather events.

Climate change impacts Ghana's water security, agricultural productivity, and biodiversity. Altered rainfall patterns and rising temperatures disrupt rain-fed agriculture, which forms the backbone of the rural economy. Coastal habitats face threats from sea-level rise and storm surges, leading to erosion, saltwater intrusion, and the loss of mangrove forests that are crucial for carbon sequestration and fisheries. This degradation weakens ecosystem services, disrupting hydrological cycles, reducing soil fertility, and increasing pest prevalence.

The loss of biodiversity threatens endemic species and compromises ecosystem services upon which many communities depend. For example, deforestation in the Atewa Range Forest Reserve, driven by agricultural expansion and



mining, fragments habitats and reduces carbon sequestration capacity, further intensifying climate risks (Foli et al., 2020). Similarly, the decline in mangroves in the Keta Lagoon Complex exacerbates marine biodiversity loss, threatening fisheries that provide livelihoods to coastal communities (Mensah et al., 2019).

Ecosystem degradation and biodiversity loss have far-reaching economic and social implications. Ghana's forestry sector, contributing significantly to GDP through timber and non-timber products, faces threats from illegal logging and governance challenges. Fisheries, another vital sector, are stressed by overfishing and climate-induced ocean warming and acidification. These challenges undermine immediate economic benefits and threaten the sustainability of dependent communities.

Culturally, Ghana's ecosystems are deeply intertwined with its people's identity and practices. Many communities regard natural sites and species as sacred, integral to their ancestral lands and cultural traditions. The loss of these resources erodes cultural heritage and social cohesion, impacting traditional practices and community resilience.

An assessment of biodiversity and ecosystems as part of Ghana's National Adaptation Plan (NAP) is vital to ensuring that adaptation strategies are scientifically grounded and effectively implemented. Such an evaluation strengthens the integration of ecosystem-based approaches into climate adaptation, aligning with both national development goals and global commitments. This process enhances the coordination of institutional efforts across governance levels and sectors, fostering more resilient and sustainable communities.

1.2. Aim and Objectives

The Sector-Specific Adaptation Plan for Ghana's Biodiversity and Ecosystems aims to address the adverse impacts of climate change on ecosystems that underpin the country's environmental and socioeconomic stability. The plan

focuses on reducing vulnerabilities and enhancing the adaptive capacity of ecosystems, species, and communities reliant on these resources. It seeks to promote sustainable biodiversity management through evidence-based approaches, policy integration, and community engagement. The overarching aim is to integrate biodiversity considerations into Ghana's National Adaptation Plan (NAP) while building resilience in the face of climate change.

The assessment is guided by the following specific objectives:

1. Conduct a comprehensive vulnerability assessment to identify species and habitats most affected by climate change, focusing on critical ecosystems such as mangroves and freshwater habitats, which play pivotal roles in coastal protection and inland fisheries.
2. Develop adaptive strategies that enhance ecosystem resilience, incorporating measures such as agroforestry, sustainable fishing practices, and ecosystem-based management approaches aligned with Ghana's commitments to the Convention on Biological Diversity (CBD).
3. Inform and influence national policy to integrate biodiversity and ecosystem considerations into development agendas, ensuring conservation measures are incorporated into planning and implementation across resource-dependent sectors.
4. Strengthen community engagement and build adaptive capacity by promoting education on sustainable resource management, facilitating access to climate-resilient practices, and empowering communities to participate in biodiversity conservation initiatives.



1.3. Justification for Assessing Ghana's Biodiversity and Ecosystems Sector

The assessment of biodiversity and ecosystems in the context of climate change adaptation under Ghana's National Adaptation Plan (NAP) is vital for several reasons. Biodiversity and ecosystems are foundational to the country's environmental health, socioeconomic stability, and climate resilience. As a nation highly dependent on natural resources for agriculture, water supply, and energy, Ghana's biodiversity directly supports critical ecosystem services that sustain livelihoods and drive economic development (Boafo et al., 2014). However, climate change poses an existential threat to these systems through rising temperatures, erratic rainfall patterns, and extreme weather events. The Millennium Ecosystem Assessment (2005) emphasizes that ecosystem degradation exacerbates the vulnerability of communities, particularly in developing countries like Ghana. Therefore, integrating biodiversity into the NAP ensures a holistic approach to safeguarding these systems against climate impacts.

One key justification for this assessment is the integral role ecosystems play in mitigating climate change effects. Forests, wetlands, and mangroves act as natural buffers, regulating water flow, sequestering carbon, and protecting against extreme weather events such as floods and droughts. Studies, including the IPCC Sixth Assessment Report (2021), highlight the potential for ecosystem-based adaptation (EbA) to enhance climate resilience while providing co-benefits such as biodiversity conservation and sustainable livelihoods. By assessing biodiversity within the NAP, Ghana can identify and implement EbA strategies tailored to local contexts, such as reforestation, mangrove restoration, and agroforestry, which are already proving effective in mitigating climate risks.

Moreover, biodiversity underpins ecosystem services critical for food security, water availability, and health. Pollination, soil fertility, and water purification are essential services at risk from climate change, particularly in agriculture-

dependent economies like Ghana. The decline in pollinator species, for instance, threaten cocoa production, a vital export commodity and income source for millions (IPBES, 2016). According to the IPBES Global Assessment Report (2019), addressing biodiversity loss is imperative for maintaining ecosystem functionality and resilience. Assessing these dynamics within the NAP framework allows Ghana to prioritize adaptive measures that secure ecosystem services and, by extension, national development goals.

Another important consideration is the role of biodiversity and ecosystems in enhancing the adaptive capacity of vulnerable communities. Coastal ecosystems such as mangroves provide protection against storm surges and coastal erosion, while savannah grasslands support pastoral livelihoods that are increasingly threatened by climate variability. Community-based adaptation approaches, such as the Community Resource Management Areas (CREMAs), have demonstrated the effectiveness of engaging local populations in biodiversity conservation. The inclusion of biodiversity in the NAP not only strengthens these initiatives but also ensures that adaptation planning incorporates the knowledge, needs, and priorities of marginalized groups, thereby promoting equity and inclusivity.

Furthermore, aligning biodiversity and ecosystem considerations with Ghana's NAP fulfills international commitments and unlocks access to global financial and technical support. The Convention on Biological Diversity's (CBD) Post-2020 Global Biodiversity Framework and the IPCC emphasize the integration of biodiversity into national and regional planning as a means to achieve transformative climate action. By embedding biodiversity within its NAP, Ghana positions itself to leverage funding mechanisms such as the Green Climate Fund (GCF) and international collaborations to implement large-scale adaptation projects.

Finally, robust assessment and integration of biodiversity into Ghana's NAP provide a foundation for effective monitoring and evaluation of adaptation outcomes. Developing indicators to track progress in biodiversity adaptation



efforts ensures transparency, accountability, and flexibility in responding to emerging challenges. Adaptive management, informed by predictive models and real-time data, can optimize resource allocation and enhance the resilience of ecosystems over time.

1.4. Gendered-Responsive Action Plan for the Biodiversity and Ecosystem Sector

A gender-responsive action plan for the biodiversity and ecosystems sector in Ghana is imperative due to the differentiated impacts of climate change on men and women and the roles they play in ecosystem management. Gender dynamics significantly influence access to and control over natural resources, decision-making, and adaptation strategies. Women in Ghana, particularly in rural communities, are often primary caregivers and custodians of biodiversity resources, such as forest products and water. However, systemic barriers limit their participation in decision-making and access to resources essential for adaptation.

Climate change exacerbates existing inequalities, making women more vulnerable to its impacts. For example, in the savannah regions of Ghana, women often rely on shea trees for income and sustenance. Increased temperatures and prolonged droughts have led to declining shea yields, directly impacting women's livelihoods. According to Adzawla et al. (2019), incorporating gender-sensitive approaches in biodiversity conservation enhances the adaptive capacity of these communities by addressing the unique vulnerabilities faced by women.

The inclusion of women in ecosystem restoration projects has proven successful in enhancing biodiversity conservation and improving livelihoods. In the mangrove restoration projects in the Volta Delta, women's participation has been pivotal in ensuring sustainable outcomes. By involving women in planting and monitoring activities, these projects have not only restored degraded ecosystems but also provided alternative income sources, reducing poverty levels.



A gender-responsive action plan recognizes and leverages the unique knowledge, skills, and contributions of women in biodiversity conservation. It ensures equitable access to resources, such as training in ecosystem-based adaptation practices and financial support for sustainable livelihoods. The Food and Agriculture Organization (FAO) and the United Nations Development Programme (UNDP) emphasize that integrating gender considerations into biodiversity strategies leads to more effective and inclusive outcomes, fostering resilience across communities.

Furthermore, addressing gender disparities in the biodiversity sector aligns with Ghana's commitments under international frameworks such as the Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW) and the Sustainable Development Goals (SDGs), particularly Goal 5 on gender equality and Goal 15 on life on land. Implementing a gender-responsive approach not only strengthens ecosystem resilience but also promotes social equity and economic empowerment.

1.5. Purpose of the Biodiversity and Ecosystem Sector Action Plan

The purpose of the Sectoral Adaptation Plan for Biodiversity and Ecosystems is to provide a strategic framework that guides Ghana's efforts to preserve and enhance ecosystem resilience in the face of climate change. This plan seeks to ensure the sustainability and functionality of biodiversity and ecosystems, thereby safeguarding critical ecosystem services, improving livelihoods, and supporting economic and cultural development.

The Action Plan emphasizes the integration of biodiversity considerations into climate change policies, programs, and strategies to promote sustainable environmental management. The key objectives include:

- **Preserve Critical Ecosystem Services:** The plan focuses on maintaining services such as water filtration, soil fertility, pollination, and carbon sequestration, which are essential for food security and climate resilience. Strategies include the conservation of mangroves, wetlands, and forest reserves, such as the Atewa Range and the Muni-Pomadze Ramsar site.
- **Enhance Community Livelihoods:** Biodiversity-based sectors such as forestry and fisheries provide vital income sources for many Ghanaians. The plan aims to support sustainable resource use, offering training and resources to communities to adapt to climate-induced changes while promoting sustainable practices such as agroforestry and sustainable fishing.
- **Strengthen Economic Resilience:** By stabilizing ecosystems, the plan helps mitigate economic losses associated with biodiversity degradation. This includes protecting timber and non-timber forest products and ensuring sustainable fisheries management to support broader economic stability and growth.
- **Promote Cultural and Heritage Conservation:** Ghana's biodiversity is deeply connected to its cultural identity. The plan seeks to safeguard sacred groves and other culturally significant sites, ensuring the preservation of traditional knowledge and practices.

The strategic actions outlined in the plan also include:

- **Comprehensive Risk Assessments:** Conducting detailed assessments to identify vulnerable species and habitats, enabling targeted intervention strategies.

- **Capacity Building and Community Engagement:** Empowering local communities with knowledge, skills, and tools to sustainably manage biodiversity and ecosystems. This includes incorporating gender-sensitive approaches to ensure equitable participation.
- **Research and Innovation:** Supporting the development of ecosystem-based adaptation solutions, such as the restoration of degraded lands and climate-resilient agricultural practices.
- **Policy Integration:** Aligning biodiversity conservation with national and regional climate adaptation policies to foster coordinated action.
- **Monitoring and Evaluation:** Establishing mechanisms to track the effectiveness of adaptation actions, ensuring adaptive management practices are employed for continuous improvement.

The Biodiversity and Ecosystem Sector Action Plan represents a critical component of Ghana's overarching strategy to address climate change. Through its emphasis on sustainability, resilience, and inclusivity, the plan provides a roadmap for protecting natural heritage while enabling communities to thrive in a changing climate.





CHAPTER 2: METHODOLOGICAL APPROACH

2.1. Data Sources

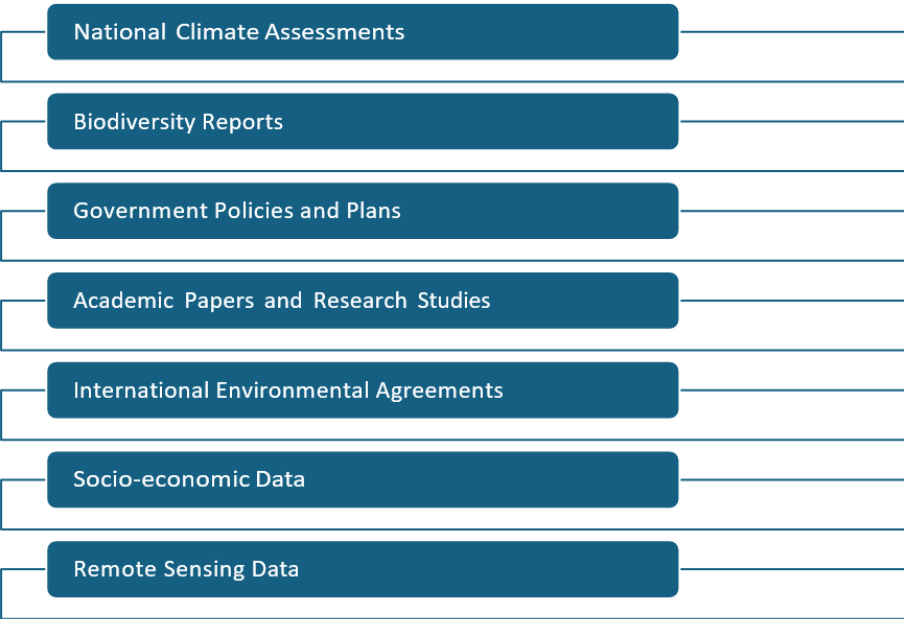
The foundation of the Sector-Specific Adaptation Plan for Ghana's biodiversity and ecosystems is built upon a robust collection of secondary data sources. These sources provide the necessary information to understand current conditions, historical trends, and potential future scenarios impacting biodiversity and ecosystem services under climate change. The following types of secondary sources were utilized:

1. **National Climate Assessments:** Comprehensive reports that provide insights into climate trends, projections, and impacts specific to Ghana. These assessments are crucial for understanding how changing climate patterns are likely to affect biodiversity and ecosystems.
2. **Biodiversity Reports:** Documents from national and international conservation organizations, such as the Ghana Wildlife Society and the International Union for Conservation of Nature (IUCN), which detail species richness, conservation status, and threats to various habitats and species within Ghana.
3. **Government Policies and Plans:** This includes the National Biodiversity Strategy and Action Plan (NBSAP) and other relevant policies from the Ministry of Environment, Science, Technology, and Innovation, which outline ongoing strategies and priorities for managing and conserving biodiversity.

4. **Academic Papers and Research Studies:** Peer-reviewed articles and university research that provide detailed analyses on specific aspects of biodiversity and ecosystems, such as species vulnerability, ecosystem resilience, and the effectiveness of various conservation strategies under climate change scenarios.
5. **International Environmental Agreements:** Documentation on agreements such as the Ramsar Convention on Wetlands and the Convention on Biological Diversity, which Ghana is a party to. These documents are critical for aligning national strategies with international commitments.
6. **Socio-economic Data:** Reports from the Ghana Statistical Service and development organizations that provide demographic, economic, and social data. This information helps to assess the human dimensions of biodiversity and ecosystem changes, including dependence on natural resources and vulnerability to environmental changes.
7. **Remote Sensing and GIS Data:** Satellite imagery and geographic information systems data that offer spatial analysis capabilities. These tools are used to track land use changes, habitat fragmentation, and other environmental transformations over time.



Figure 1: Data Sources for Biodiversity and Ecosystem Sector Assessment



2.2. Analytical Approach

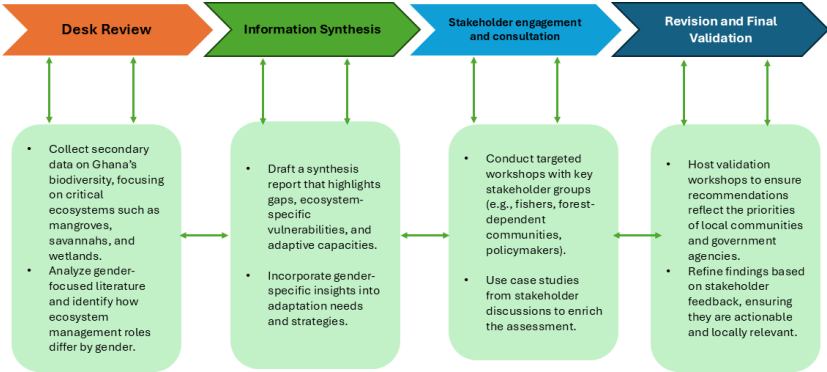
The analytical framework for the biodiversity and ecosystems assessment in Ghana is structured to ensure a robust, inclusive, and context-specific evaluation of vulnerabilities and adaptive capacities ((Figure 2). Each stage in this framework builds on the preceding steps, creating a seamless flow of information and stakeholder engagement that culminates in actionable recommendations. The framework’s structure reflects the need for a comprehensive understanding of ecosystem vulnerabilities, local perspectives, and targeted adaptation strategies that align with Ghana’s National Adaptation Plan (NAP). Below is a detailed description of each stage in the framework.

2.2.1. Desk Review

The desk review serves as the foundational step of biodiversity and ecosystems assessment. This phase involves the systematic collection and analysis of secondary data to provide a comprehensive understanding of Ghana’s biodiversity and ecosystems. Key focus areas include the critical roles of mangroves, savannahs, wetlands, and forests, along with their respective vulnerabilities to climate change.

The desk review also includes the analysis of gender-disaggregated information and gender-focused literature to understand how ecosystem management roles differ by gender. This ensures the inclusion of social dimensions in the assessment. By compiling data from government reports, peer-reviewed studies, and existing policy documents, this phase establishes a solid evidence base to inform subsequent steps. Insights gained from the desk review guide the focus of stakeholder consultations and information synthesis, ensuring relevance and depth.

Figure 2. Overall work approach for the Climate Change Risk Assessment for the Biodiversity and Ecosystem Sector



2.2.2. Information Synthesis

The information synthesis phase translates the raw data collected during the desk review into a coherent synthesis report. This report identifies ecosystem-specific vulnerabilities, adaptive capacities, and knowledge gaps. Organizing the data thematically, the synthesis highlights trends such as mangrove degradation, deforestation in the Atewa Range, and the impacts of sea-level rise on wetlands.

An essential component of this stage is incorporating gender-specific insights into the synthesis. This involves analyzing how gender roles and responsibilities influence vulnerability and adaptation strategies. For example, the unique roles of women in managing mangrove resources are assessed alongside men's contributions to forest governance. These insights set the stage for stakeholder discussions and further refinement of findings.

2.2.3. Stakeholder Engagement and Consultation

Stakeholder engagement was a key phase in the assessment, ensuring that the outcomes reflected local realities and priorities. This phase involved targeted workshops with diverse stakeholder groups, including fishers, forest-dependent communities, policymakers, and local NGOs. The input gathered from stakeholders was instrumental in validating the findings from the synthesis report and identifying additional vulnerabilities and opportunities that might have been overlooked during earlier stages.

During the workshops, participants provided valuable insights into local ecosystem dynamics, challenges, and practical adaptation measures. For instance, fishers highlighted the impacts of declining mangrove ecosystems on fisheries, while forest-dependent communities shared their perspectives on the implications of deforestation on their livelihoods. This participatory

approach not only enriched the assessment with diverse perspectives but also fostered a sense of ownership among the stakeholders. Their contributions ensured that the assessment was comprehensive, contextually relevant, and aligned with the needs and priorities of those most affected by ecosystem changes.

2.2.4. Revision and Final Validation

The final stage involved revising and validating the assessment based on feedback from stakeholders. These revisions ensured that all insights, particularly those from local communities and marginalized groups, were thoroughly integrated into the final report. This phase emphasized aligning the assessment with Ghana's national policies and international commitments, including frameworks such as the Convention on Biological Diversity.

The validation process included dedicated workshops where stakeholders reviewed the revised document to confirm its accuracy, relevance, and feasibility. The finalized report emerged as a strategic tool to guide biodiversity and ecosystem adaptation efforts. It incorporated clear, actionable recommendations informed by the collective insights of stakeholders, ensuring the plan's credibility and practicality for implementation. This comprehensive approach reinforced the assessment's potential to drive impactful and inclusive adaptation strategies.

2.3. Methodology

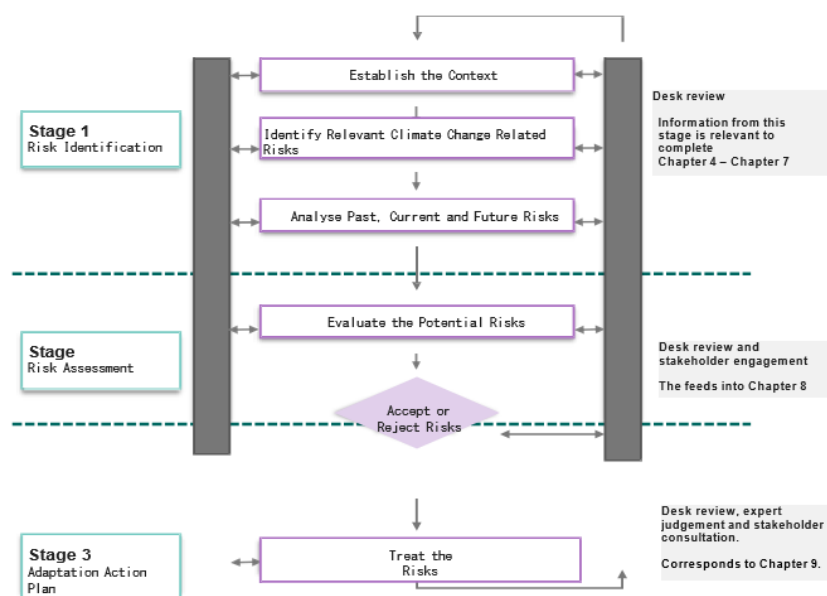
2.3.1. Biodiversity and Ecosystems Risk Assessment

The Biodiversity and Ecosystems Risk Assessment for Ghana adopted a methodology similar to that of Norman et al. (2014), adapted to the unique context of biodiversity and ecosystems. This structured approach is divided into three primary stages, each addressing specific components



of risk identification, assessment, and management (see **Figure XXX**). The methodology also integrates gender dimensions to ensure a comprehensive and equitable evaluation of vulnerabilities and adaptive capacities in the biodiversity and ecosystems sector.

Figure 3. Methodology for Climate Change Risk Assessment (CCRA) in Biodiversity and Ecosystem Sector



Source: Adapted from (Norman, et al., 2014)

Stage 1: Risk Identification

The first stage of the risk identification process for biodiversity and ecosystems involved establishing the assessment context. This step defined the parameters influencing climate risk management for Ghana's diverse

ecosystems, such as forests, mangroves, and wetlands. Desk reviews formed a critical part of this stage, focusing on gathering and analyzing relevant information from existing literature, reports, and datasets. These reviews explored historical trends, ecosystem-specific vulnerabilities, and socio-economic attributes to provide a foundational understanding of the risks to biodiversity and ecosystems.

Once the context was established, the next step was identifying potential climate change-related risks to biodiversity and ecosystems. These risks included habitat loss, species range contractions, ecosystem degradation, and increased frequency of extreme weather events. The identification process highlighted how these risks threaten ecosystem services essential to livelihoods and economic activities in Ghana. This stage laid the groundwork for analyzing the risks in greater detail and informed the design of the subsequent risk assessment process.

Stage 2: Risk Assessment

The second stage involved analyzing the identified risks to evaluate their potential impacts and likelihood. This phase was crucial in understanding the severity and implications of the risks, enabling informed decision-making for adaptive action. The risk assessment began with a detailed analysis of past, current, and projected climate risks to biodiversity and ecosystems. Historical events, such as flooding impacts on mangroves in the Volta Delta or deforestation in the Atewa Range, were analyzed alongside current trends to project future scenarios.

Desk reviews and stakeholder engagement were key activities in this stage. The desk reviews focused on synthesizing scientific reports, case studies, and historical data to understand the nature and extent of risks. Stakeholder engagement involved targeted workshops with key groups, including conservation organizations, community representatives, and



government agencies, to gather diverse perspectives and validate findings. This participatory approach ensured that the risk assessment captured local realities and priorities.

The findings were meticulously documented, with hazards examined and prioritized based on their potential consequences and likelihood of occurrence. Key considerations in this prioritization process included the severity of impacts on critical ecosystems, the financial costs associated with adaptation, and the implications for vulnerable groups reliant on these ecosystems. This thorough decision-making process provided a strategic foundation for developing the Biodiversity and Ecosystems Adaptation Action Plan. It ensured that resources and efforts were directed toward addressing the most pressing threats, thereby enhancing the plan's effectiveness and relevance in mitigating climate and environmental risks.

Stage 3: Adaptation Action Plan

The final stage of the methodology focused on formulating and implementing an Adaptation Action Plan to address the identified risks. The primary objective of the adaptation action plan was to enhance the resilience of Ghana's biodiversity and ecosystems to climate change impacts, ensuring the continuity of ecosystem services essential for livelihoods and sustainable development.

The adaptation action plan outlined specific strategies and actions for mitigating risks, including timelines, responsibilities, and required resources. Key strategies included reforestation, mangrove restoration, sustainable land management, and community-based conservation initiatives. The plan also integrated gender-responsive measures to address the unique vulnerabilities and contributions of men and women in managing biodiversity resources.

Monitoring and evaluation mechanisms were incorporated into the adaptation action plan to track the effectiveness of the implemented strategies. These mechanisms provided a feedback loop, enabling adjustments to actions based on observed outcomes and emerging challenges.

The methodology emphasized a collaborative approach, leveraging diverse expertise and stakeholder inputs to shape the risk assessment and action plan. This process ensured the development of a robust, contextually tailored strategy for biodiversity and ecosystem adaptation in Ghana, aligning with the country's National Adaptation Plan and international commitments such as the Convention on Biological Diversity (CBD).

2.3.2. Identification and Compilation of Sector-Specific Adaptation Actions

The development of the National Adaptation Action Plan for the Biodiversity and Ecosystem Sector involved a meticulous process to identify, evaluate, and compile targeted adaptation strategies. This process ensured that the actions proposed were tailored to address the unique vulnerabilities of ecosystems while fostering resilience and sustainability. The planning team utilized a robust methodology, detailed in **Table 1**, to determine these adaptation options.



Table 1. Methodology to Identify Adaptation Options

Methodology	Description
Vulnerability Assessment Report Recommendations	The vulnerability assessments conducted for Ghana's biodiversity and ecosystems provided actionable recommendations for adaptation. These assessments identified the key risks and vulnerabilities facing various ecosystems, such as forests, wetlands, and marine areas, and proposed specific measures to mitigate them. These recommendations formed a critical foundation for the planning process.
Literature Review	An extensive review of scientific literature, government policy documents, management plans for protected areas, and global best practices was undertaken. The review included strategies for conserving biodiversity in similar climatic and socio-economic contexts, such as mangrove restoration in coastal areas and afforestation efforts in semi-arid zones.
Stakeholder Consultation	Engagement with a wide range of stakeholders, including government agencies, local communities, non-governmental organizations, academic institutions, and private sector actors, ensured the inclusion of diverse perspectives. Participatory workshops facilitated discussions of climate scenarios, potential adaptation measures, and implementation challenges. Ecosystem-specific stakeholders, such as forest managers, fisheries authorities, and conservation NGOs, provided critical input.

Source: Author's construct (2024)

Following the compilation of potential adaptation measures, an evaluation and prioritization process was undertaken to ensure the effectiveness, feasibility, and sustainability of the proposed actions (Table 2). This process

involved assessing the suitability of each option in enhancing ecosystem resilience, reducing vulnerabilities, and contributing to sustainable development. Stakeholders from diverse backgrounds were actively involved to ensure the selected measures were context-specific, equitable, and free from maladaptive outcomes.

To facilitate this process, a Multicriteria Decision Making (MCDM) Analysis was employed. MCDM is a systematic framework that enables the evaluation and prioritization of multiple options based on predefined criteria. The methodology helps address the complexities of decision-making in sectors where trade-offs may exist among competing objectives, such as conservation, economic development, and community well-being.

Table 2. Criteria for Evaluating Adaptation Options in the Biodiversity and Ecosystem Sector

Criteria	Description
Ecological Effectiveness	Measures the potential of the action to enhance ecosystem resilience and protect biodiversity.
Feasibility	Assesses the technical, financial, and operational viability of implementing the adaptation measure.
Social Equity	Evaluates the extent to which the action promotes inclusivity and benefits vulnerable and marginalized groups.
Cost-Effectiveness	Considers the economic efficiency of the measure, including long-term benefits relative to its costs.
Sustainability	Assesses the ability of the adaptation action to provide enduring benefits without degrading resources.



Stakeholder Acceptance	Evaluates the level of community and institutional support for the proposed measure.
Policy Alignment	Determines how well the adaptation action aligns with national policies, international frameworks, and sectoral goals.

Source: Adapted from Dixit & McGray (2013)

The MCDM framework allowed stakeholders to assign weights to each criterion, reflecting its relative importance to the biodiversity and ecosystem sector. Proposed adaptation actions were then scored against these criteria, ensuring a transparent and participatory prioritization process. For instance, actions such as mangrove restoration, forest conservation, and community-based wetland management were evaluated for their ecological benefits, cost-efficiency, and alignment with Ghana's National Climate Change Policy and Sustainable Development Goals.

After ranking the various indicators, assigning appropriate weights to them was a critical step in the prioritization process. A weighted scoring system was employed, where indicators were evaluated based on their relative importance to the biodiversity and ecosystem sector.

Unlike equal weighting systems, this approach allowed for a nuanced evaluation that reflected the specific needs and priorities of the sector (Zobeidi et al., 2024; Antwi-Agyei et al., 2013; UNFCCC, 2011).

To achieve this, a five-point Likert scale was used to rank the indicators (**Table 3**). This method engaged climate change experts, biodiversity conservationists, and ecosystem management professionals who provided rankings based on their expertise and the perceived importance of each indicator. Drawing inspiration from the methodology used by Antwi-Agyei et al. (2013), the frequency and consensus with which each indicator

was cited contributed to the final weighting system (Zobeidi et al., 2024; UNFCCC, 2011).

Table 3. Ranking of Adaptation Options

Rank	Interpretation
1	Low
2	Neutral
3	Medium
4	High
(....)	Enclosed number indicates high uncertainty

This ranking framework provided a structured and transparent method for integrating expert insights into the decision-making process. Additionally, the inclusion of a mechanism to denote high uncertainty (e.g., enclosing a number in brackets) allowed for greater flexibility and caution in interpreting results, particularly in areas where data or consensus was limited. The finalized weighting and ranking system thus ensured that adaptation options were not only scientifically rigorous but also contextually appropriate for the biodiversity and ecosystem sector.





CHAPTER 3: CURRENT STATE OF BIODIVERSITY AND ECOSYSTEMS IN GHANA

3.1. Background

Ghana's diverse biodiversity and ecosystems are fundamental to the country's ecological, social, and economic well-being. Stretching from the lush tropical high forests of the southwest to the expansive savannahs of the north, Ghana's ecosystems are home to a remarkable diversity of plant and animal species. These ecosystems provide critical ecological services, including climate regulation, water purification, soil fertility maintenance, and pollination, which are indispensable to the country's agriculture, forestry, fisheries, and overall economic development. Forest reserves, wetlands, rivers, and coastal areas also contribute significantly to food security, medicinal resources, and income generation, particularly for rural communities that depend directly on these natural resources for their livelihoods.

However, despite their immense value, Ghana's biodiversity and ecosystems face unprecedented pressures. Anthropogenic activities such as deforestation, mining, overfishing, and agricultural expansion, coupled with climate change impacts, have led to the rapid degradation of natural habitats and a decline in species populations. According to Ghana's National Biodiversity Strategy and Action Plan (NBSAP, 2016), the country has lost more than 30% of its forest cover since 1990, while wetlands and coastal ecosystems are increasingly threatened by urbanization, pollution, and rising sea levels. Furthermore, the country's biodiversity hotspots, such as the Atewa Range Forest Reserve and the Keta

Lagoon Complex, are under significant stress, jeopardizing their capacity to sustain ecological services and economic benefits. These challenges underscore the urgent need for robust conservation and sustainable management strategies to protect Ghana's biodiversity and ecosystems.

Biodiversity loss in Ghana is not only an ecological issue but also a socio-economic and cultural challenge. Many communities, especially in rural areas, rely heavily on biodiversity for traditional medicine, food, and energy needs. Sacred groves, often protected by cultural norms, play a critical role in biodiversity conservation while also serving as repositories of cultural heritage. However, the weakening of traditional governance systems and the increasing demand for land and natural resources are eroding these cultural practices, further exacerbating biodiversity loss. Recognizing the interconnectedness of biodiversity, ecosystem services, and human well-being, Ghana has prioritized biodiversity conservation through international commitments such as the Convention on Biological Diversity (CBD) and national initiatives like the Community Resource Management Areas (CREMAs). These efforts aim to align biodiversity conservation with socio-economic development, ensuring a sustainable future for both people and nature.

3.2. Overview of Biodiversity and Ecosystems Sector in Ghana

Ghana's diverse ecosystems are a cornerstone of its ecological and socio-economic fabric, supporting a wide array of plant and animal species while providing essential services such as water purification, climate regulation, and food production. These ecosystems, ranging from tropical forests to coastal mangroves, play a critical role in sustaining livelihoods, enhancing biodiversity, and driving economic growth. An understanding of the categories of biodiversity and ecosystems in Ghana is essential for identifying conservation priorities and ensuring the sustainable management of these valuable natural resources.



3.2.1. Forests

Ghana's forests are categorized into distinct vegetation belts based on climatic, ecological, and geographical variations. These forests play a critical role in biodiversity conservation, climate regulation, and supporting livelihoods.

3.2.1.1 Wet Evergreen (Rainforest)

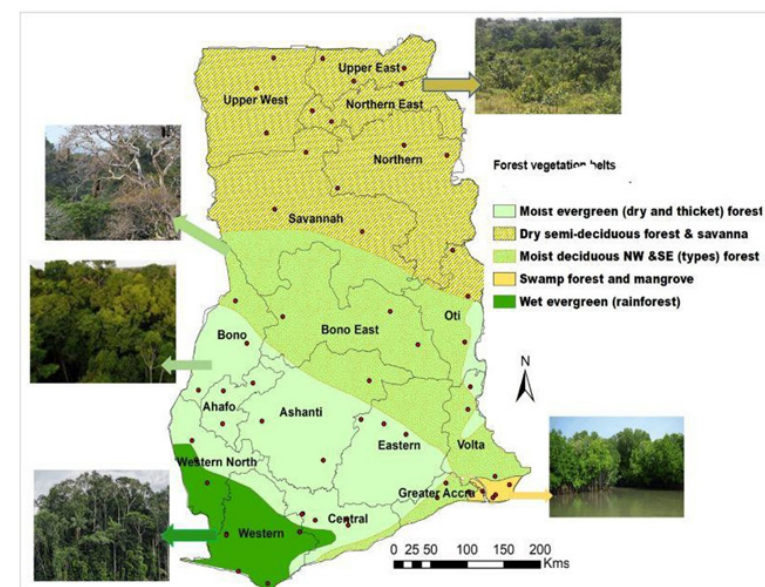
The wet evergreen forests of Ghana are primarily located in the Western and Western North Regions. These forests receive high levels of rainfall and are characterized by dense canopies that support exceptional biodiversity. They include critical conservation areas such as the Ankasa Conservation Area and Bia National Park, which are home to unique species including forest elephants, pygmy hippopotamuses, and various endemic plant species such as *Celtis mildbraedii* and *Heritiera utilis*. Additionally, the forests are rich in timber species like Odum (*Milicia excelsa*) and Mahogany (*Khaya spp.*), which are crucial to the timber industry. The forests also harbor a variety of bird species, including the white-necked picathartes, and serve as habitats for numerous amphibians and reptiles.

3.2.1.2 Moist Evergreen (Dry and Thicket Forest)

Moist evergreen forests are found in regions such as Bono, Bono East, and Ahafo. These forests serve as a transitional zone between the wet evergreen forests and drier forest types. They are characterized by moderately dense vegetation that supports a range of biodiversity. Notable flora includes tree species such as *Mansonia altissima* and *Ceiba pentandra*, while faunal species include duikers, bushbucks, and several species of primates. The

Tano Offin and Bosomtwe Range Forest Reserves within this zone are known for their ecological richness, including various medicinal plants and smaller mammals like pangolins. These forests play a significant role in local ecosystems, providing both timber and non-timber forest products that are essential for community livelihoods.

Figure 4. Forest-vegetation belts. Image of the forest features/ layers, regions.



Source: Nyarko et al. 2023

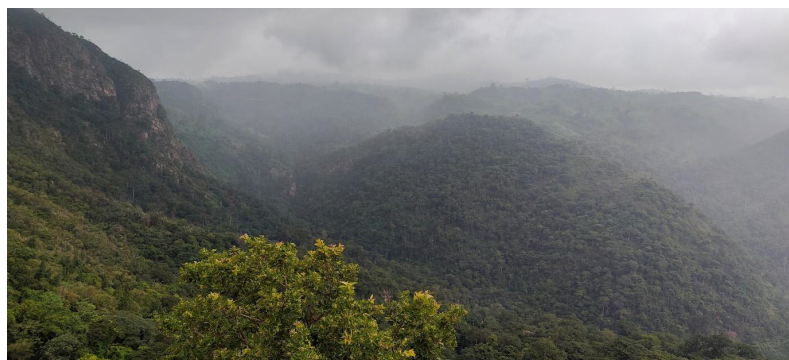
3.2.1.3 Moist Deciduous (Northwest and Southeast Types) Forest

The moist deciduous forests, located in the Ashanti, Central, and Eastern Regions, are seasonally dry forests characterized by their diverse flora and fauna. Dominant tree species include *Triplochiton*



scleroxylon (Wawa) and *Terminalia superba* (Ofram), which are valued for their high-quality timber. These forests are also home to a variety of wildlife, including antelopes, bush pigs, and numerous bird species such as the hornbill. The moist deciduous forests are critical for pollination services and the production of medicinal plants. They provide habitats for economically significant species like bees and butterflies, which contribute to agricultural productivity.

Plate 1: Forest ecosystem from Mountain Afadjato



Source: Boafo, YA (2024)

3.2.1.4 Dry Semi-Deciduous Forest and Savannah

Dry semi-deciduous forests and savannahs occur in the transitional zones, including parts of the Savannah, Upper East, and Upper West Regions. These ecosystems are characterized by a mix of drought-resistant trees, such as Shea (*Vitellaria paradoxa*) and Baobab (*Adansonia digitata*), interspersed with grasslands. Mole National Park, located in the savannah zone, is an exemplary area within this typology. It supports significant populations of large mammals such as elephants, kobs, and buffaloes, alongside various bird species. The park also serves as a critical site for research and conservation,

contributing to the sustainable management of Ghana's savannah ecosystems. Non-timber products like shea butter and dawadawa (*Parkia biglobosa*) highlight the economic potential of this forest type.

Plate 2. Elephant in the Mole National Park



Source: Boafo, YA (2023)

3.2.1.5 Swamp Forests and Mangroves

Swamp forests and mangroves are predominantly found along Ghana's coastline, particularly in the Volta and Greater Accra Regions. The Keta Lagoon Complex and Densu Delta represent key areas of this ecosystem type. These forests are dominated by mangrove species such as *Rhizophora racemosa* and *Avicennia germinans*, which provide essential services like coastal protection, carbon storage, and fish breeding. The biodiversity within these ecosystems includes aquatic species such as crabs, mollusks, and fish like tilapia, which are vital for local livelihoods. Additionally, they serve as nesting grounds for migratory birds, including flamingos



and herons. These ecosystems also play a crucial role in mitigating the impacts of storm surges and rising sea levels (**Plate 3**).

Plate 3. Mangrove vegetation located in Ada Foah. Greater Accra region



Source: Boafo, YA (2024)

Table 4: Biodiversity found in each forest typology in Ghana

Forest Typology	Biodiversity Types
Wet Evergreen (Rainforest)	Forest elephants, pygmy hippopotamuses, Odum, Mahogany, white-necked picathartes, various amphibians, and reptiles
Moist Evergreen (Dry and Thicket Forest)	Mansonia altissima, Ceiba pentandra, duikers, bushbucks, pangolins, medicinal plants, over 266 bird species, and butterfly diversity

Moist Deciduous (Northwest and Southeast Types)	<i>Triplochiton scleroxylon</i> (Wawa), <i>Terminalia superba</i> (Ofram), antelopes, bush pigs, hornbills, bees, butterflies, and ecotourism opportunities like Kakum’s canopy walkway
Dry Semi-Deciduous Forest and Savannah	Shea (<i>Vitellaria paradoxa</i>), Baobab (<i>Adansonia digitata</i>), guinea fowls, hares, squirrels, monitor lizards, elephants, kobs, and buffaloes
Swamp Forests and Mangroves	<i>Rhizophora racemosa</i> , <i>Avicennia germinans</i> , tilapia, crabs, mollusks, flamingos, and herons

3.2.2. Wetland Ecosystems

3.2.2.1 Ramsar Sites

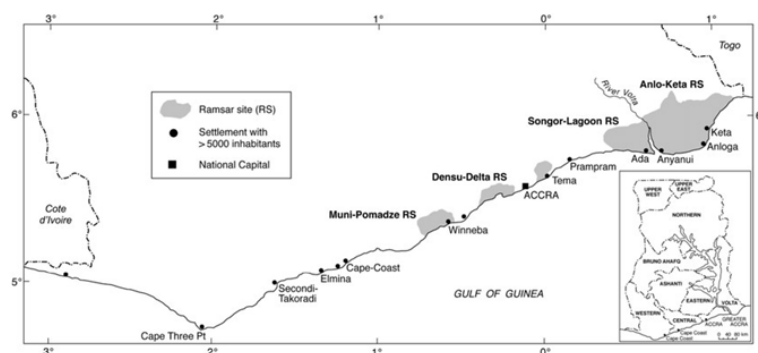
Ghana is home to six designated Ramsar sites: Keta Lagoon, Songor, Sakumo Lagoon, Densu Delta, Muni-Pomadze Lagoon, and Owabi Wildlife Sanctuary. These wetlands play a pivotal role in biodiversity conservation and providing critical ecosystem services. The Keta Lagoon, located in the Volta Region, supports a diverse array of fish species and is a crucial breeding ground for tilapia and catfish, contributing significantly to local fisheries. Migratory birds such as terns, sandpipers, and plovers utilize the lagoon as a stopover point, enhancing its international ecological importance.

Similarly, the Sakumo Lagoon, near Accra, serves as a habitat for several waterfowl species, including egrets and herons. The Densu Delta, another vital Ramsar site, supports mangrove species like



Rhizophora racemosa and *Avicennia germinans*, which provide shelter for mollusks and crabs. Meanwhile, the Owabi Wildlife Sanctuary, located in the Ashanti Region, serves as a significant water source for Kumasi city and harbors a variety of aquatic species and migratory birds. These Ramsar sites collectively support fisheries, regulate floods, and serve as sources of food, medicines, and fuel for local communities.

Figure 5. Map of Ghana showing the five demarcated coastal wetlands (Ramsar sites) under the CWMP. Source: Dovie, 2003



3.2.2.2 Inland Wetlands

In Ghana, inland wetlands include freshwater systems such as rivers, lakes, and reservoirs that sustain agriculture, fisheries, and biodiversity (**Table 5**). The Volta River, the largest freshwater system in the country, supports a range of biodiversity, including Nile tilapia, African catfish, and aquatic vegetation crucial for fisheries. The river also provides irrigation for agriculture and acts as a habitat for endangered species like the African manatee.

Another critical inland wetland is Lake Bosomtwe, located in the Ashanti Region. It is Ghana's only natural lake and harbors unique species like *Tilapia busumana*, a fish species endemic to the lake. These wetlands also support bird species, including the African jacana and white-faced whistling duck. Inland wetlands are integral to water purification, sediment retention, and as habitats for migratory bird species, further enhancing their ecological significance.

3.2.2.3 Coastal Wetlands

Ghana's coastal wetlands, including lagoons, estuaries, and mangroves, are crucial ecosystems along the country's shoreline. The Sakumo Lagoon, located near Tema, is a vital breeding ground for fish and a habitat for migratory birds such as the black-tailed godwit and yellow wagtail. Similarly, the Densu Delta, near Accra, acts as a buffer against coastal erosion and supports artisanal fisheries, providing livelihoods for local communities.

Mangrove forests in these wetlands, particularly in the Keta Lagoon Complex, serve as nurseries for juvenile fish, crabs, and shrimp. They also act as natural barriers, protecting coastal areas from storm surges and erosion. These mangroves sequester carbon, playing a significant role in mitigating climate change. Additionally, the Muni-Pomadze Lagoon supports migratory birds like flamingos and provides critical ecosystem services such as storm protection and water filtration.



Plate 4: Keta lagoon wetland taken from Anyanui



Table 5: Biodiversity in Wetland Ecosystems in Ghana

Wetland Type	Species (Scientific Name)	Local Name
Ramsar Sites	<i>Oreochromis niloticus</i> (Nile Tilapia), <i>Phoenicopterus minor</i> (Lesser Flamingo), <i>Phragmites australis</i> (Common Reed)	Akosombo Fish, Dzanoma
Inland Wetlands	<i>Heterotis niloticus</i> (African Bonytongue), <i>Trichechus senegalensis</i> (African Manatee), <i>Nymphaea lotus</i> (Water Lily)	Manatee Fish, Nkyene

Coastal Wetlands	<i>Rhizophora mangle</i> (Red Mangrove), <i>Cardisoma armatum</i> (Rainbow Crab), <i>Ciconia ciconia</i> (White Stork)	Mangrove, Edwene
Keta Lagoon	<i>Mugil cephalus</i> (Flathead Grey Mullet), <i>Charadrius alexandrinus</i> (Kentish Plover), <i>Avicennia germinans</i> (Black Mangrove)	Tilapia, Odum
Songor Lagoon	<i>Ethmalosa fimbriata</i> (Bonga Shad), <i>Laguncularia racemosa</i> (White Mangrove), <i>Himantopus himantopus</i> (Black-winged Stilt)	Shad Fish, Mangrove
Densu Delta	<i>Sarotherodon melanotheron</i> (Blackchin Tilapia), <i>Egretta garzetta</i> (Little Egret), <i>Rhizophora racemosa</i> (Red Mangrove)	Black Tilapia, Egret

3.2.3. Marine Ecosystems

The marine ecosystem encompasses Ghana's Exclusive Economic Zone (EEZ), characterized by its rich marine biodiversity. Ghana's EEZ spans approximately 225,000 square kilometers and supports diverse marine life, making it a cornerstone of local and commercial fisheries. The ecosystem



is divided into coastal waters, continental shelf, and deeper ocean zones, each playing a critical ecological and economic role (**Plate 5**).

Plate 5. Portion of Ghana's Coastline from Beyin in the Ellembelle District of Western Region



The continental shelf, stretching along Ghana's coastline, hosts significant benthic biodiversity, including crustaceans like crabs and lobsters. Coral reefs, though limited, provide essential habitats for species such as parrotfish (*Scarus spp.*) and groupers (*Epinephelus spp.*). Coastal waters are rich in pelagic fish such as *Scomber japonicus* (Atlantic mackerel) and *Sardinella aurita* (Round sardinella), vital for artisanal and industrial fisheries. These marine resources not only sustain local livelihoods but also contribute significantly to Ghana's economy through exports.

Table 6: Biodiversity in Marine Ecosystems in Ghana

Marine Ecosystem Zone	Species (Scientific Name)	Local Name
Coastal Waters	<i>Scomber japonicus</i> (Atlantic Mackerel), <i>Sardinella aurita</i> (Round Sardinella)	Amanzese, Eban
Continental Shelf	<i>Scarus spp.</i> (Parrotfish), <i>Epinephelus spp.</i> (Grouper)	Ebunam, Akyekyede
Benthic Zone	<i>Callinectes amnicola</i> (Blue Crab), <i>Panulirus regius</i> (Spiny Lobster)	Nkran Kokro, Nsoroma
Coral Reefs	<i>Pseudanthias squamipinnis</i> (Sea Goldie), <i>Acanthurus spp.</i> (Surgeonfish)	Nsuo Nsuro

3.2.4. Aquatic Ecosystems

3.2.4.1 Rivers and Lakes

Ghana's rivers and lakes are crucial components of its aquatic ecosystems, supporting diverse biodiversity and essential ecosystem services. Major rivers, such as the Volta, Pra, Tano, and Ankobra, provide critical habitats for freshwater species. These rivers are home to species like the African catfish (*Clarias gariepinus*), Nile tilapia (*Oreochromis niloticus*), and the West African lungfish (*Protopterus annectens*). Lake Volta, one of the largest man-made



reservoirs in the world, supports endemic fish species such as *Tilapia busumana* and plays a vital role in irrigation, hydropower, and water supply for domestic and industrial use (Table 7).

3.2.4.2 Artificial Reservoirs

Artificial reservoirs, created for irrigation, hydropower, and other purposes, also contribute significantly to Ghana's aquatic biodiversity. Reservoirs like the Weija and Bui Reservoirs provide habitats for species such as the African clawed frog (*Xenopus laevis*) and various freshwater crustaceans. These reservoirs are integral to local livelihoods, supporting fisheries and providing water for agriculture and communities.

Table 7. Biodiversity in Aquatic Ecosystems in Ghana

Aquatic Ecosystem Type	Species (Scientific Name)	Local Name
Rivers	<i>Clarias gariepinus</i> (African Catfish), <i>Oreochromis niloticus</i> (Nile Tilapia)	Nsuo Mpatoa, Akosombo
Lakes	<i>Tilapia busumana</i> (Bosumtwi Tilapia), <i>Protopterus annectens</i> (West African Lungfish)	Apese, Nsuo Kotrim
Artificial Reservoirs	<i>Xenopus laevis</i> (African Clawed Frog), <i>Macrobrachium rosenbergii</i> (Giant Freshwater Prawn)	Ntotro, Nsuo E

3.3. Trends and Patterns of Biodiversity and Ecosystems

The biodiversity and ecosystems sector in Ghana exhibits distinct trends and patterns that reflect the complex interplay of natural and anthropogenic factors. These trends are critical for understanding the current health of ecosystems, guiding conservation efforts, and

developing sustainable policies. This section explores the condition and trajectory of Ghana's terrestrial, wetland, marine, and aquatic ecosystems.

3.3.1. Forests

Ghana's forests, comprising wet evergreen, moist deciduous, gallery, and dry semi-deciduous types, are under severe pressure from various anthropogenic activities (Table 8). These ecosystems, rich in biodiversity and crucial for ecosystem services such as carbon sequestration and water regulation, are increasingly degraded due to deforestation, agricultural expansion, illegal mining, and logging. Figure 6 displays the spatial distribution of forest reserves across Ghana, with notable concentrations in regions such as Western, Ashanti, Ahafo, and Bono, known for their wet and moist forests. In contrast, the Northern and Savannah regions show sparser reserves, reflecting their savannah landscapes.

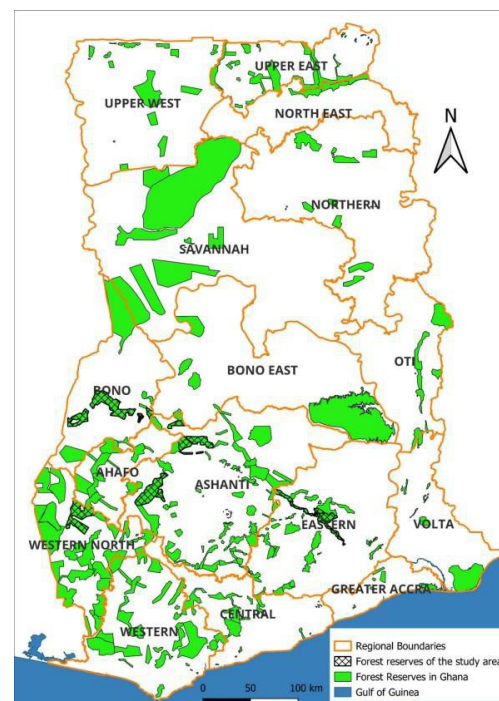
The wet evergreen forests, primarily located in the Western and Western North Regions, are biodiversity hotspots hosting species like forest elephants (*Loxodonta africana cyclotis*), pygmy hippopotamuses (*Choeropsis liberiensis*), and endemic plants such as *Celtis mildbraedii*. Despite their ecological importance, these forests are rapidly losing their integrity. Illegal logging and agricultural expansion, particularly for cocoa farming, are major drivers of deforestation in these regions. Compounding these threats is illegal mining, locally referred to as *galamsey*, which has become one of the most destructive forces. Mining activities clear large



tracts of forest, leaving behind open pits and degraded land, while the use of mercury and cyanide contaminates nearby water bodies. The Ankasa Conservation Area, though relatively intact, faces encroachment that jeopardizes its 800+ vascular plant species and critical wildlife populations.

In the Ashanti Region, the moist deciduous forests, including the Tano Offin Forest Reserve, are similarly impacted. Agricultural encroachment is a significant driver of habitat fragmentation, but *galamsey* exacerbates the problem by destroying forest cover and polluting water sources. The heavy sedimentation of rivers caused by mining runoff affects aquatic habitats and reduces water quality for surrounding communities. Species like bush pigs (*Potamochoerus porcus*) and duikers, which rely on intact forest ecosystems, are increasingly vulnerable to habitat loss.

Figure 6. Forest reserves in Ghana Source: Narh, 2024



Gallery forests, found along riverbanks in the Northern, Upper East, and Upper West Regions, are critical for biodiversity and hydrological stability. These forests provide habitat for species such as crocodiles (*Crocodylus niloticus*) and otters (*Aonyx capensis*), as well as vegetation like *Ficus spp.* and *Albizia spp.*, which stabilize riverbanks and prevent soil erosion. However, land conversion for agriculture and the expansion of mining activities have significantly degraded these ecosystems. Mining along rivers, particularly in the Black Volta Basin, has led to increased sedimentation,



reducing the capacity of these forests to support wildlife and maintain water quality.

The dry semi-deciduous forests and savannahs, which are dominant in the Savannah, Bono East, and Northern Regions, face a different set of challenges. Charcoal production, illegal logging, and agricultural expansion are the primary threats to these ecosystems. While *galamsey* is less prominent in these areas, its cumulative impact on Ghana's forest ecosystems is profound. The widespread deforestation and pollution caused by illegal mining activities disrupt ecological balance, threaten biodiversity, and compromise the provision of ecosystem services.

Table 8. Key Forest Types in Ghana: Regional Distribution, Species, and Challenges

Region	Forest Type	Notable Species	Issues
Western and Western north Regions	Wet Evergreen	Forest elephants, pygmy hippopotamuses	Deforestation, <i>galamsey</i> , logging
Ashanti Region	Moist Deciduous	Bush pigs, duikers	Agricultural encroachment, <i>galamsey</i>
Northern Region	Gallery Forests	Crocodiles, otters	Land conversion, water quality degradation
Savannah Region	Dry Semi-Deciduous	Baobab, shea	Charcoal production, deforestation

Source: Author's Construct, 2024

The destruction caused by *galamsey* has far-reaching consequences. In addition to clearing forests, mining activities disrupt soil structures, making reforestation efforts challenging. The pollution of water bodies with heavy metals threatens both aquatic biodiversity and the health of communities relying on these water sources. Moreover, the loss of forest cover contributes to climate change by reducing carbon sequestration and increasing greenhouse gas emissions. The cumulative impact of these issues underscores the urgent need for robust policies and enforcement mechanisms to safeguard Ghana's forest ecosystems.

3.3.2. Wetland Ecosystems

Wetland ecosystems in Ghana, encompassing Ramsar sites, inland wetlands, and coastal wetlands, are critical for biodiversity conservation, ecosystem services, and local livelihoods. These ecosystems regulate floods, purify water, and provide habitats for diverse species. However, they face numerous challenges, including pollution, habitat degradation, and urban encroachment (Table 9).

Ghana's six Ramsar sites—Keta Lagoon, Songor Lagoon, Sakumo Lagoon, Densu Delta, Muni-Pomadze Lagoon, and Owabi Wildlife Sanctuary—are vital for both biodiversity and human communities. The Keta Lagoon, located in the Volta Region, is a significant site for migratory bird species such as flamingos (*Phoenicopterus spp.*) and herons (*Ardea spp.*). It also supports artisanal fishing, which sustains the livelihoods of thousands. However, salt mining and urbanization around the lagoon are causing habitat loss and water pollution. Similarly, the Sakumo Lagoon near Tema, an important breeding ground for fish and migratory birds, is heavily impacted by waste dumping and residential development.

Inland wetlands, such as the floodplains of the Volta River and Lake Bosomtwe, play crucial roles in agriculture, fisheries, and water regulation. Lake Bosomtwe, a UNESCO Biosphere Reserve, supports endemic fish



species such as *Tilapia busumana*. However, this inland wetland is under stress from eutrophication caused by agricultural runoff and invasive species like water hyacinth (*Eichhornia crassipes*). The Volta River floodplains provide habitats for aquatic species, support irrigation for farming, and sustain inland fisheries. Nonetheless, dam construction and water abstraction upstream have altered flow regimes, reducing wetland functionality and biodiversity.

Coastal wetlands, including lagoons, estuaries, and mangrove forests, are indispensable for fish breeding, storm protection, and carbon sequestration. The Densu Delta, located near Accra, is a vital mangrove ecosystem providing nursery grounds for fish species like tilapia (*Oreochromis niloticus*) and crustaceans such as mangrove crabs (*Sesarma* spp.). Mangroves in areas like the Keta Lagoon Complex and the Densu Delta act as natural buffers against coastal erosion and storm surges. Despite their importance, mangrove cover is declining at an annual rate of 3% due to overharvesting for firewood, urban expansion, and aquaculture development (EPA, 2022).

Pollution remains a significant issue for wetland ecosystems across Ghana. Industrial waste, agricultural runoff, and plastic pollution have degraded water quality, threatening aquatic biodiversity. For example, the Songor Lagoon in the Greater Accra Region is heavily polluted with effluents from nearby industries, affecting fish populations and the health of local communities reliant on these wetlands for drinking water and food.

Table 9. Key Wetland Types in Ghana: Notable Sites, Species, and Challenges

Wetland Type	Notable Sites	Key Species	Issues
Ramsar Sites	Keta Lagoon, Sakumo Lagoon	Flamingos, herons, tilapia	Urban encroachment, pollution
Inland Wetlands	Volta River, Lake Bosomtwe	Nile tilapia, endemic <i>Tilapia busumana</i>	Eutrophication, invasive species
Coastal Wetlands	Densu Delta, Keta Lagoon Complex	Mangrove crabs, mudskippers.	Mangrove degradation, overharvesting

Source: Author's Construct, 2024

Wetlands are also culturally significant, with many local communities relying on them for spiritual practices and traditional medicine. However, the degradation of these ecosystems threatens not only biodiversity but also the cultural heritage and socioeconomic well-being of these communities.

3.3.3. Marine Ecosystems

Ghana's marine ecosystems, encompassing its Exclusive Economic Zone (EEZ), coastal waters, continental shelf, and limited coral reefs, are critical for sustaining fisheries, supporting livelihoods, and providing essential ecosystem services. However, these ecosystems face significant challenges, including overfishing, pollution, habitat destruction, and climate change (Table 10).

Ghana's coastal waters are highly productive, supporting pelagic fish species essential for both artisanal and industrial fisheries. Key species



include sardines (*Sardinella aurita*), anchovies (*Engraulis encrasicolus*), and mackerels (*Scomber japonicus*). These species form the backbone of the local fishing economy, contributing to food security and export revenues. Despite their economic importance, fish stocks have declined by an estimated 25% over the past decade due to overfishing, illegal, unreported, and unregulated (IUU) fishing practices, and habitat degradation (Fisheries Commission, 2022).

Artisanal fishers along the coast in regions like Western, Central, and Greater Accra report dwindling catches, forcing them to travel farther offshore, increasing operational costs and reducing profitability. The use of destructive fishing practices, such as light fishing and the use of fine-mesh nets, exacerbates the depletion of fish stocks, disrupting marine food webs and threatening biodiversity.

The continental shelf, extending up to 200 nautical miles from Ghana's coast, is a biologically diverse zone that supports benthic species like blue crabs (*Callinectes amnicola*), spiny lobsters (*Panulirus regius*), and various mollusks. These species are not only ecologically significant but also economically valuable, particularly for export markets.

However, the health of this ecosystem is under threat. Bottom trawling, a widespread practice in Ghana's industrial fisheries, damages benthic habitats and reduces biodiversity. Additionally, sedimentation caused by land-based activities such as illegal mining (*galamsey*) and coastal construction impacts water clarity and smothers benthic organisms, reducing their ability to thrive. For example, sediment inflows into the Ankobra River estuary have degraded habitats for benthic species, affecting their reproductive cycles and population dynamics.

Although coral reefs are limited in Ghana, they provide essential habitats for marine species such as parrotfish (*Scarus spp.*), damselfish (*Pomacentridae*

spp.), and sea urchins (*Diadema spp.*). These reefs contribute to coastal protection by mitigating wave energy and reducing erosion along Ghana's shores.

Coral reefs in areas like Cape Three Points are increasingly under stress due to rising sea temperatures, leading to coral bleaching events. Climate change exacerbates this issue, with projections from the Intergovernmental Panel on Climate Change (IPCC) indicating further warming of coastal waters, which could accelerate bleaching and reduce reef resilience. In addition to temperature stress, coastal pollution from oil spills, agricultural runoff, and plastic waste further deteriorates reef health, impacting the species that depend on these habitats.

Table 10. Key marine ecosystems, notable species and issues

Marine Ecosystem Zone	Notable Species	Issues
Coastal Waters	Sardines (<i>Sardinella aurita</i>), mackerels (<i>Scomber japonicus</i>)	Overfishing, IUU fishing
Continental Shelf	Blue crabs (<i>Callinectes amnicola</i>), spiny lobsters (<i>Panulirus regius</i>)	Sedimentation, bottom trawling
Coral Reefs	Parrotfish (<i>Scarus spp.</i>), sea urchins (<i>Diadema spp.</i>)	Coral bleaching, pollution

Source: Author's construct, 2024

Marine ecosystems are integral to the livelihoods of coastal communities, supporting artisanal fishers and providing employment for processors and traders, many of whom are women.



Additionally, these ecosystems have cultural significance, with certain species and coastal areas considered sacred or central to traditional practices.

3.3.4. Aquatic Ecosystems

Ghana's aquatic ecosystems, comprising rivers, lakes, and artificial reservoirs, are vital for biodiversity, agriculture, hydropower, and domestic water supply. These ecosystems also play significant cultural and economic roles in the lives of local communities. However, they face challenges such as pollution, invasive species, overextraction of water resources, and climate-induced changes (Table 11).

Ghana's major rivers, including the Volta, Pra, Tano, and Ankobra, are lifelines for freshwater biodiversity and local livelihoods. These rivers provide habitats for key species such as African catfish (*Clarias gariepinus*), Nile tilapia (*Oreochromis niloticus*), and electric fish (*Mormyrus spp.*). The rivers also support riparian vegetation, which stabilizes soil and regulates water flow.

The Volta River, the longest in Ghana, feeds into Lake Volta, one of the largest man-made reservoirs in the world. Lake Volta is a critical hub for fisheries, sustaining endemic species like Tilapia busumana and supporting large-scale aquaculture operations. However, invasive species such as the water hyacinth (*Eichhornia crassipes*) and pollution from agricultural runoff and mining effluents pose significant threats. For example, illegal mining along the Pra River has increased sedimentation levels, reducing water quality and negatively impacting aquatic biodiversity.

The Tano River, another key waterway, provides vital ecosystem services for agriculture and drinking water. However, excessive water abstraction and agricultural encroachment along its banks have degraded aquatic

habitats, threatening species such as African softshell turtles (*Trionyx triunguis*).

Ghana's artificial reservoirs, such as the Bui Reservoir and the Weija Reservoir, are designed for irrigation, hydropower, and urban water supply. These reservoirs also provide habitats for aquatic species, contributing to local fisheries and biodiversity.

The Bui Reservoir, created by damming the Black Volta River, supports species like the giant freshwater prawn (*Macrobrachium rosenbergii*) and African clawed frog (*Xenopus laevis*). Additionally, the surrounding riparian vegetation provides critical ecosystem services such as water filtration and habitat connectivity. However, the inundation of large areas for reservoir construction has disrupted terrestrial and aquatic ecosystems, impacting species migration patterns and altering water quality.

Table 11. Key Aquatic Ecosystems in Ghana: Locations, Biodiversity, and Environmental Challenges

Aquatic Ecosystem Type	Key Locations	Notable Species	Issues
Rivers	Volta, Pra, Tano, Ankobra	African catfish (<i>Clarias gariepinus</i>), Nile tilapia (<i>Oreochromis niloticus</i>)	Illegal mining, pollution
Lakes	Lake Volta, Lake Bosomtwe	Tilapia busumana, electric fish (<i>Mormyrus spp.</i>)	Invasive species, eutrophication



Artificial Reservoirs	Bui, Weija	Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>), African clawed frog (<i>Xenopus laevis</i>)	Urban encroachment, sedimentation
-----------------------	------------	--	-----------------------------------

The Weija Reservoir, which supplies water to Accra, supports a variety of fish species, including tilapia and catfish, critical for local fisheries. However, urban encroachment and pollution from nearby settlements are degrading the reservoir's water quality. Nutrient inflows from agricultural activities upstream have led to eutrophication, reducing oxygen levels and affecting aquatic life.

Pollution remains one of the most pressing issues for Ghana's aquatic ecosystems. Agricultural runoff, laden with fertilizers and pesticides, contaminates rivers and lakes, causing eutrophication and reducing fish stocks. Illegal mining (galamsey) is another significant threat, particularly along rivers like the Pra and Ankobra, where mercury contamination impacts both biodiversity and human health.

Invasive species such as water hyacinths exacerbate these challenges by choking waterways, reducing oxygen availability, and hindering navigation. Climate change further compounds these issues by altering rainfall patterns and reducing water availability in some regions, threatening the resilience of aquatic ecosystems.

Aquatic ecosystems in Ghana are home to a diverse array of species. Fish such as electric fish (*Mormyrus spp.*), Nile tilapia (*Oreochromis niloticus*), and African pike (*Hepsetus odoe*) are vital for local fisheries. Amphibians like the African clawed frog (*Xenopus laevis*) and reptiles like the Nile monitor lizard (*Varanus niloticus*) contribute to ecological balance and biodiversity.

These ecosystems also provide critical ecosystem services, including water purification, flood regulation, and the provision of fish and other aquatic resources for food and livelihoods. Cultural services are equally significant, with many rivers and lakes holding spiritual importance for local communities.





CHAPTER 4: NATIONAL CLIMATE CHANGE TRENDS

4.1. Country Overview

This section provides an overview of Ghana and examines climate change trends to understand the context of biodiversity and ecosystem management. It highlights key geographic, demographic, and economic characteristics essential for understanding the vulnerabilities and adaptive capacity of Ghana's biodiversity and ecosystems.

4.1.1. Geographic Location

Ghana is situated in West Africa along the Gulf of Guinea, bordered by Côte d'Ivoire to the west, Burkina Faso to the north, and Togo to the east. It spans latitudes 4°44'N to 11°11'N and longitudes 1°11'E to 3°15'W, covering approximately 238,533 square kilometers (World Bank, 2024) (**Figure 7**). Its 560-kilometer southern coastline is rich in marine biodiversity, featuring lagoons, mangroves, and estuaries that are crucial for fish breeding and coastal protection. The country's geographic location near the equator influences its tropical climate, which includes distinct wet and dry seasons that shape its diverse ecosystems, from rainforests in the south to savannahs in the north. This positioning also makes Ghana a biodiversity hotspot, hosting flora and fauna that are critical to regional ecological balance (World Bank, 2024).

4.1.2. Country Profile

Ghana encompasses a variety of ecosystems, including forests, wetlands, savannahs, and marine areas, which are distributed across 12 distinct vegetation zones. Forests cover 41% of the total land area, while 69%

is allocated to agriculture (FAO, 2020). Agricultural expansion has significantly contributed to deforestation and habitat loss, with agricultural land increasing from 55% in 1990 to 69% in 2017 (World Bank, 2020). Ghana's ecosystems include critical biodiversity hotspots like the Ankasa Conservation Area, which supports wet evergreen forests, and the Mole National Park, which represents savannah ecosystems. Despite these riches, Ghana's biodiversity faces threats from habitat degradation, illegal mining, and urbanization.

The country is home to diverse wetlands, including six Ramsar sites such as the Keta Lagoon and Songor Lagoon, which are essential for migratory birds and fisheries. Coastal ecosystems, particularly mangroves along the Gulf of Guinea, serve as buffers against storm surges while supporting local livelihoods. Inland water bodies like the Volta River and Lake Bosomtwe host endemic fish species and provide vital ecosystem services such as irrigation and hydropower generation.



Figure 7.Location of Ghana Source: World Atlas, 2024



4.1.3. Demographic Characteristics

Ghana’s population, estimated at over 32 million people, has a young demographic profile, with nearly 57% of the population under 25 years old (World Bank, 2024). This youth-dominated structure offers opportunities for community-based conservation and sustainable resource management initiatives. Ethnically diverse groups such as the Akan, Mole-Dagbani, Ewe, and Ga-Dangme contribute to the cultural and traditional practices that influence biodiversity conservation. Urbanization is increasing, with 56% of the population residing in cities like Accra, Kumasi, and Sekondi-Takoradi, where urban expansion and infrastructure development pose challenges to natural habitats.

Rural communities, which depend heavily on biodiversity for agriculture, fishing, and traditional medicine, are particularly vulnerable to ecosystem degradation. Community-based initiatives have proven effective in engaging these populations in conservation efforts, particularly in areas like the Northern Region, where savannah ecosystems are central to livelihoods.

4.1.4. Key Economic Sectors

Ghana’s economy is intricately linked to its natural resources, with key sectors such as agriculture, forestry, fisheries, and tourism heavily reliant on biodiversity and ecosystems. Forestry contributes significantly to GDP through timber and non-timber products, including shea butter and medicinal plants, which are crucial for both local and export markets. Fisheries, including artisanal and aquaculture, are critical for food security and employ a substantial portion of the population, particularly in coastal and inland areas (Fisheries Commission, 2023).

The tourism sector thrives on Ghana’s natural heritage, with sites like Kakum National Park and Mole National Park attracting both local and



international visitors. These parks not only conserve biodiversity but also contribute to the economy by generating revenue and creating jobs. However, mining and energy, particularly gold extraction and oil production, have emerged as significant threats to ecosystems, contributing to habitat destruction and pollution.

Small and medium enterprises (SMEs) in the informal sector play a crucial role in resource-dependent activities such as charcoal production and bushmeat trade, which, while economically significant, pose sustainability challenges. Strengthening regulations and promoting sustainable practices in these sectors are essential for balancing economic growth with biodiversity conservation.

4.2. Climate Trends and Variability in Ghana

Ghana's tropical climate, influenced by the West African monsoon winds, plays a significant role in shaping the country's diverse ecosystems and biodiversity. The movement of the Inter-Tropical Convergence Zone (ITCZ) between the north and south dictates seasonal rainfall and temperature patterns, which, in turn, affect forest health, wetland integrity, and marine ecosystems. Seasonal variations are most pronounced in the northern regions, where temperatures range from 27°C to 30°C during the hot, dry season (April to June) (Asante & Amuakwa-Mensah, 2015). The two primary seasons — the wet season (April to October) and the dry season (November to March) are driven by distinct monsoon systems. The wet season is dominated by southwest monsoons from the Atlantic Ocean, while the dry season experiences the northeast trade winds, bringing dry, dusty Harmattan conditions from the Sahara Desert.

The average annual temperature across the country is approximately 27°C, with minimal variation, though regional differences exist. Coastal areas, characterized by higher humidity, tend to be cooler than the inland and northern regions, which experience hotter and drier conditions. Annual rainfall ranges from 800 mm in

the north to 2000 mm in the south, with the majority falling during the wet season (The World Bank Group, 2024). These climatic gradients support a range of ecosystems, from wet evergreen forests in the south to savannah grasslands in the north, each hosting unique biodiversity and providing critical ecosystem services.

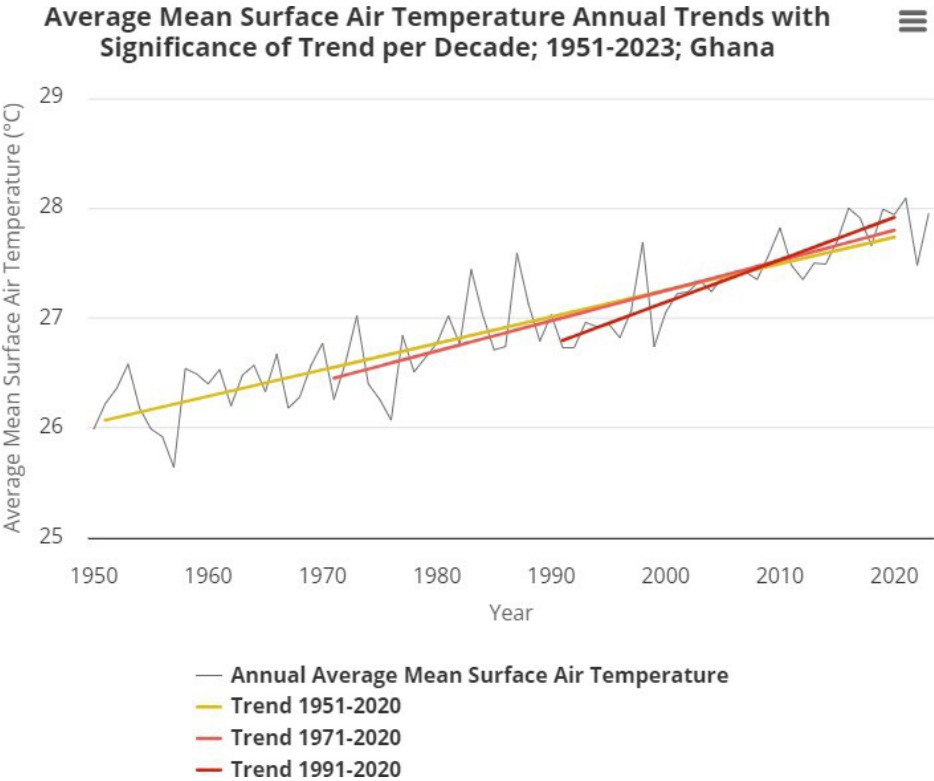
Over the past decades, Ghana has experienced significant climatic changes that have profoundly affected its biodiversity and ecosystems:

- **Temperature Increases:** Near-surface temperatures have risen by approximately 0.20–0.25°C per decade during both wet and dry seasons (**Figure 8**). This warming trend poses a threat to species with narrow thermal tolerances, such as amphibians and certain fish species, which are critical to wetland ecosystems (The World Bank Group, 2024). Elevated temperatures in savannah regions are also causing shifts in vegetation, favoring drought-resistant species while reducing habitat suitability for others.
- **Rainfall Declines and Variability:** Annual rainfall has decreased by approximately 2.4% per decade, with the northern and coastal regions experiencing the most pronounced declines (**Figure 9**). This reduction, coupled with more erratic and unpredictable rainfall patterns, has led to increased frequency and intensity of droughts and floods (Dickinson et al., 2017). For example, wetlands like the Songor Lagoon have faced prolonged dry periods, affecting waterbird populations and fish breeding cycles. In forests, reduced rainfall contributes to drying soils, increasing the vulnerability of species reliant on moist environments.
- **Humidity and Sunshine Trends:** Relative humidity has declined by 0.6% per decade, particularly during the dry season. This decline exacerbates desiccation in sensitive habitats, such as gallery



forests, which depend on stable moisture levels. Additionally, a reduction in sunshine hours by 0.8% per decade, primarily due to increased cloud cover and aerosols, affects photosynthesis and evapotranspiration, critical processes for maintaining forest and wetland productivity (The World Bank Group, 2024).

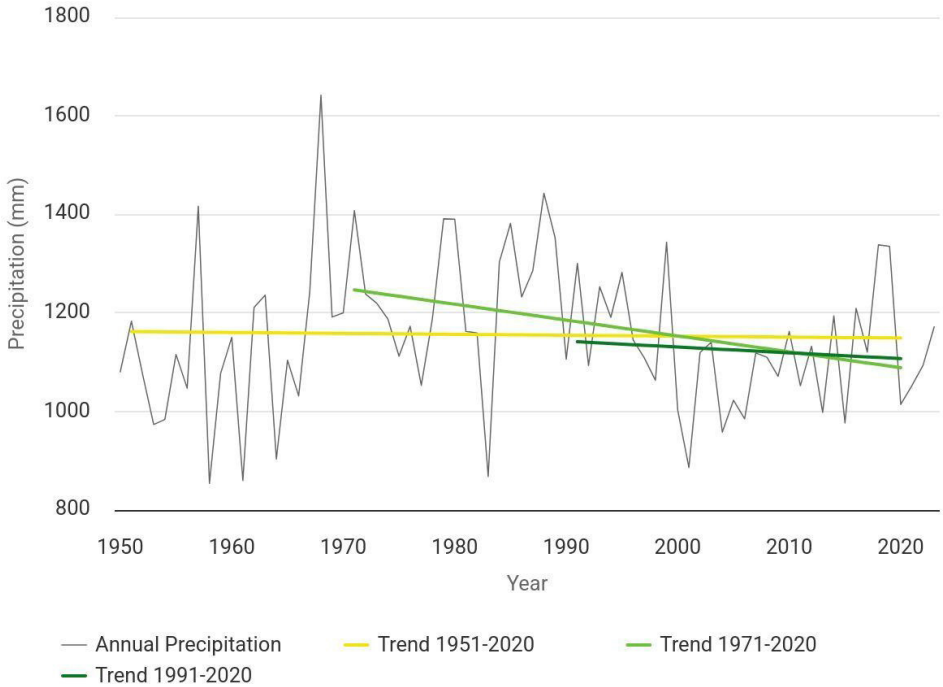
Figure 8: Average mean surface air temperature annual trends with the significance of trend per decade; 1951 – 2023; Ghana



Source: The World Bank Group (2024)

Figure 9: Precipitation annual trends with the significance of trend per decade; 1951 – 2023; Ghana Source: The World Bank Group (2024)

Precipitation Annual Trends with Significance of Trend per Decade; 1951-2023; Ghana



4.3. Projected Climate Trends

Ghana's future climate is expected to undergo significant changes driven by greenhouse gas emissions and global warming. These projections suggest critical shifts in temperature, rainfall patterns, and sea levels, which will profoundly impact biodiversity and ecosystems. The following are key climate projections for Ghana and their implications for ecological resilience, species survival, and ecosystem services.

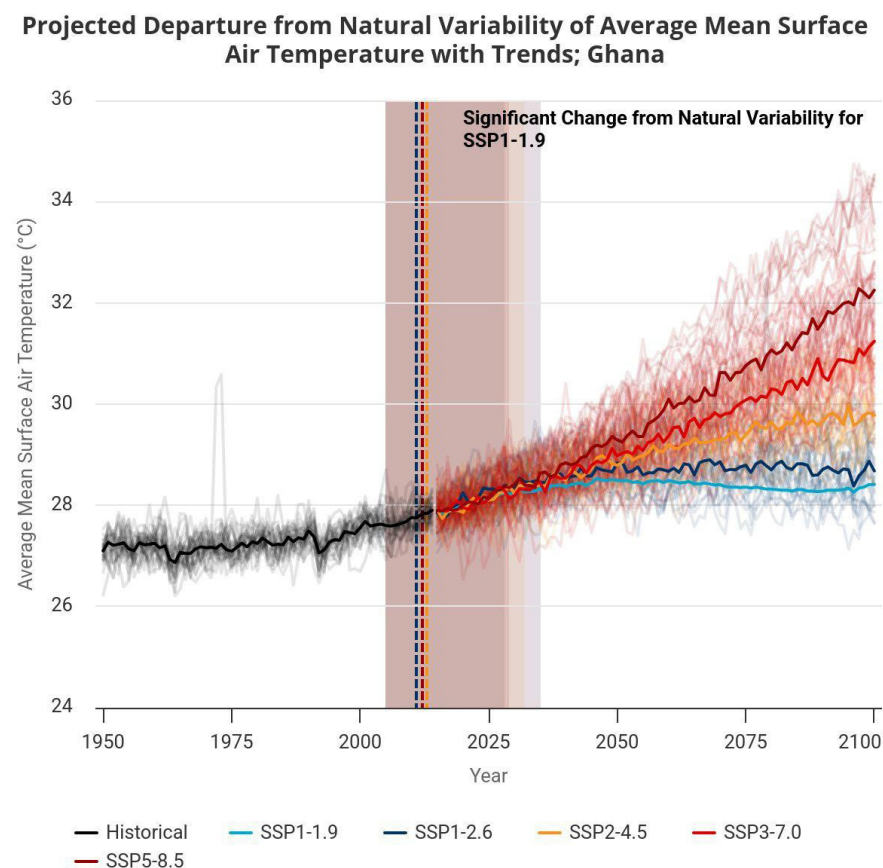


4.3.1. Temperature Projections

Near-surface temperatures are projected to increase by 1.5–3.0°C by 2050 and 2.0–5.0°C by 2080, depending on the emission scenario (The World Bank Group, 2021) (**Figure 10**). This warming trend is likely to be more severe in the northern savannah regions, exacerbating heat stress on drought-sensitive species and ecosystems. Species adapted to cooler or stable temperatures, such as amphibians and certain forest plants, may face increased mortality rates or migration pressures.

The projected rise in sea-surface temperatures of 1.0–2.0°C by 2050 and 1.5–3.0°C by 2080 will impact marine biodiversity, particularly coral reefs and fisheries. Warmer waters are expected to intensify coral bleaching events, reducing habitat availability for species such as parrotfish (*Scarus spp.*) and damselfish (*Pomacentridae spp.*). Elevated sea temperatures may also alter fish migration patterns, threatening livelihoods dependent on artisanal fishing.

Figure 10: Projected departure from the natural variability of average mean surface air temperature with trends; Ghana



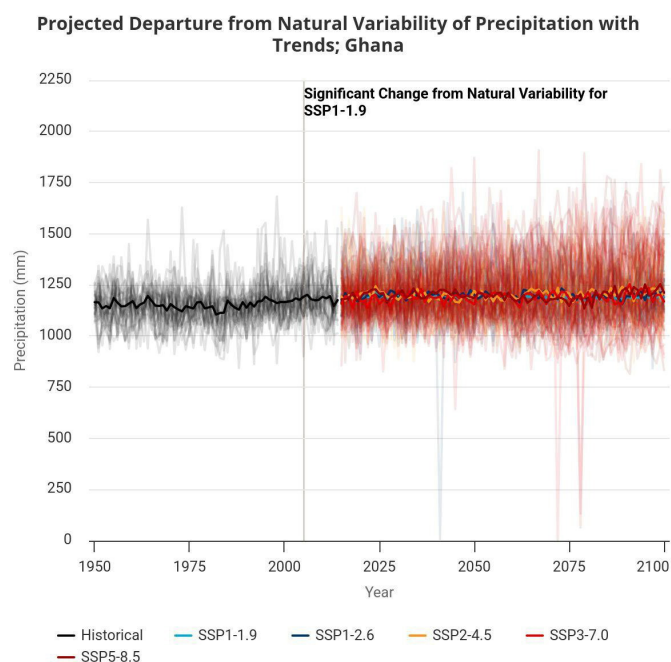
Source: The World Bank Group (2024)



4.3.2. Rainfall Projections

Annual rainfall is projected to decline by 10–20% by 2050 and 15–30% by 2080, with reductions most pronounced in the northern and coastal regions (The World Bank Group, 2024) (**Figure 11**). A shorter and more erratic wet season, characterized by delayed onset and earlier cessation, will reduce water availability for wetland and aquatic ecosystems. Critical wetlands such as the Sakumo Lagoon and Keta Lagoon may experience reduced inflows, impacting their capacity to support fish breeding, migratory birds, and water purification services.

Figure 11: Projected departure from the natural variability of precipitation with trends; Ghana Source: The World Bank Group (2024)



Increased rainfall variability and unpredictability, coupled with extreme events like heavy downpours, are likely to intensify flood risks. Flooding may damage wetland habitats, particularly in low-lying coastal regions, while simultaneously increasing sedimentation and nutrient loads in rivers and lakes, adversely affecting aquatic species. For instance, increased flooding in the Volta Basin could disrupt freshwater ecosystems and displace endemic species like *Tilapia busumana*.

4.3.3. Sea Level Rise

Sea levels are expected to rise by 0.2–0.4 meters by 2050 and 0.3–0.6 meters by 2080 (The World Bank Group, 2021c). This rise poses a direct threat to coastal ecosystems, including mangroves, lagoons, and estuaries. Coastal erosion, saltwater intrusion, and habitat loss are anticipated, particularly in the Greater Accra and Volta regions. Mangroves, vital for carbon sequestration and storm protection, could experience significant degradation, affecting species like the blue crab (*Callinectes amnicola*) and various mollusks.





CHAPTER 5: CLIMATE CHANGE IMPACTS AND VULNERABILITY ANALYSIS OF THE BIODIVERSITY AND ECOSYSTEM SECTOR

5.1. Introduction

An understanding of how different ecosystems and biodiversity components are vulnerable to climate change is crucial for developing effective adaptation and mitigation strategies. Forests, wetlands, marine, and aquatic ecosystems all experience varying degrees of exposure and sensitivity to climate risks. For instance, forests face deforestation and habitat fragmentation exacerbated by drought and illegal activities, while coastal and marine ecosystems are increasingly compromised by rising sea levels and warming waters. Moreover, wetlands and aquatic ecosystems grapple with water scarcity and pollution, further diminishing their ecological integrity and ability to support biodiversity.

This chapter explores the specific impacts of various climate risks on Ghana's biodiversity and ecosystems. It provides a comprehensive vulnerability analysis to identify the most at-risk systems, offering insights into how these changes undermine ecosystem services essential for human well-being.

5.2. Effects of Climate Change on Forest Ecosystems

Ghana's forests, which include wet evergreen, moist deciduous, dry semi-deciduous, and transitional gallery forests, are critical for biodiversity, carbon sequestration, and the livelihoods of communities. However, they are increasingly threatened by climate change risks such as rising temperatures, erratic rainfall, extreme weather events, and human-induced pressures like illegal mining and agricultural expansion.

5.2.1. Temperature-Related Risks

Rising temperatures exacerbate forest drying, which disrupts plant growth and affects forest-dependent species. For instance, wet evergreen forests in the Western and Western North Regions, home to species such as the forest elephant (*Loxodonta africana cyclotis*) and pygmy hippopotamus (*Choeropsis liberiensis*), are losing their moisture-rich microhabitats. This threatens the survival of endemic plants like *Celtis mildbraedii* and *Heritiera utilis*. These forests, particularly in areas like the Ankasa Conservation Area, play a vital role in carbon storage and hydrological regulation, making their degradation a major concern for both biodiversity and climate mitigation efforts (Forestry Commission, 2023).

5.2.2. Rainfall Variability and Decline

Erratic rainfall patterns significantly impact the regeneration capacity of moist deciduous forests in the Ashanti and Eastern Regions. Reduced precipitation lowers soil moisture levels, impairing tree species such as *Terminalia superba* (Ofram) and *Triplochiton scleroxylon* (Wawa), which are important for both ecological stability and timber production. The fragmentation of these forests due to declining rainfall further isolates wildlife populations, making them vulnerable to local extinction. For example, duikers (*Cephalophinae*) and bush pigs (*Potamochoerus porcus*)



are experiencing shrinking habitats, forcing them to venture closer to human settlements, increasing the risk of human-wildlife conflicts (Asante & Amuakwa-Mensah, 2015).

5.2.3. Extreme Weather Events

Flooding and strong winds exacerbate soil erosion and tree fall in transitional gallery forests along rivers like the Pra, Ankobra, and Tano. These forests, which serve as vital corridors for species like otters (*Lutra maculicollis*) and crocodiles (*Crocodylus suchus*), are losing structural integrity due to sedimentation and uprooted trees. The destruction of riparian vegetation not only affects biodiversity but also reduces the ecosystem's ability to stabilize riverbanks and filter water. For instance, the Bosomtwe Range Forest Reserve in the Ashanti Region has reported increased soil erosion and habitat degradation following extreme weather events (Ghana Environmental Protection Agency, 2020).

5.2.4. Deforestation and Illegal Mining (Galamsey)

Illegal mining (galamsey) poses one of the most severe threats to Ghana's forests. Activities associated with galamsey strip away vegetation, leaving barren landscapes prone to erosion and contamination. In the Western and Western North Regions, vast tracts of wet evergreen forests, including parts of the Kakum and Ankasa conservation areas, have been cleared for illegal mining. This has led to the pollution of water bodies such as the Offin and Pra Rivers with heavy metals like mercury, which further endangers aquatic and riparian ecosystems (Mensah et al., 2019).

Plate 6. Evidence of illegal gold mining activities in Boinso, Western North Region of Ghana



In the Eastern Region, galamsey activities have degraded sections of the Atiwa Forest, which is a critical biodiversity hotspot and a source of drinking water for millions. This forest, home to unique species such as the white-naped mangabey (*Cercocebus lunulatus*), is facing unprecedented biodiversity loss due to habitat destruction. Similarly, in the Ashanti Region, moist deciduous forests near Obuasi are being converted into mining sites, reducing forest cover and impacting species like pangolins (*Manis spp.*), which rely on these habitats for survival (Forestry Commission, 2022).

5.2.5. Fragmentation and Agricultural Expansion

The expansion of agriculture further fragments forests, reducing connectivity and increasing edge effects that alter microclimates within forest patches (Kokou et al., 2024). In the Bono East Region, the conversion of forested areas into cocoa plantations has resulted in habitat loss for species such as bushbucks (*Tragelaphus scriptus*) and hornbills. Fragmentation also reduces genetic diversity, making species more vulnerable to diseases and environmental changes (FAO, 2022).



Table 12. Risks and Vulnerabilities Impacting Forest Ecosystems: Biodiversity and Community Examples from Ghana

Risks and Vulnerabilities	Impacts	Examples from Forest Zones and Communities
Rising Temperatures	Forest drying reduces moisture levels, threatening regeneration and habitats for key species.	In the Ankasa Conservation Area (Western Region), rising temperatures have led to the drying of streams, affecting aquatic life and the forest elephant population (<i>Loxodonta africana cyclotis</i>).
Erratic Rainfall	Reduced precipitation limits growth of timber species like Ofram (<i>Terminalia superba</i>) and Wawa (<i>Triplochiton scleroxylon</i>), affecting biodiversity.	In the Ashanti Region, the Tano Offin Forest Reserve experiences irregular rainfall, hampering tree regeneration and reducing habitat for bush pigs (<i>Potamochoerus porcus</i>).
Flooding	Increased sedimentation and waterlogging degrade riparian habitats, affecting aquatic and terrestrial biodiversity.	Gallery forests along the Ankobra River (Western Region) experience frequent flooding, impacting species like otters (<i>Lutra maculicollis</i>) and crocodiles (<i>Crocodylus suchus</i>).

Strong Winds	Tree uprooting and canopy loss lead to habitat destruction and microclimate changes.	In the Bosomtwe Range Forest Reserve (Ashanti Region), strong winds during storms have caused extensive tree falls, reducing habitat quality for forest birds and small mammals.
Deforestation and Illegal Mining (Galamsey)	Habitat destruction and contamination endanger endemic species and reduce forest ecosystem services.	In the Atiwa Forest (Eastern Region), illegal mining has degraded critical habitats for the white-naped mangabey (<i>Cercocebus lunulatus</i>), while mercury pollution affects water quality for downstream communities.
Fragmentation and Agricultural Expansion	Loss of connectivity impacts species movement and reduces genetic diversity.	In the Bono East Region, the conversion of forested areas into cocoa plantations has fragmented habitats for hornbills and other forest-dependent birds.

Source: Author's construct (2024)

5.3. Effects of Wetland Ecosystems

Ghana's wetlands, comprising Ramsar sites, inland wetlands, and coastal wetlands, are vital for biodiversity conservation, water regulation, and local livelihoods. These ecosystems support diverse species, provide critical ecological services, and sustain economic activities such as fishing and agriculture.



However, climate change and human activities are exerting significant pressures, threatening their health and functionality.

5.3.1. Rising Temperatures

Rising temperatures accelerate water evaporation in wetlands, reducing water levels and altering their hydrological balance. In the Keta Lagoon Complex Ramsar site, reduced water levels have negatively impacted fish populations like tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*), which are vital for local livelihoods. The drying of wetlands also affects migratory birds such as the lesser flamingo (*Phoenicopterus minor*), which depend on these habitats during their migratory routes (EPA, 2021; Ministry of Environment, Science, Technology, and Innovation [MESTI], 2022).

5.3.2. Erratic Rainfall Patterns

Unpredictable rainfall disrupts the seasonal inundation cycles of wetlands, impacting biodiversity and ecological services. For example, the Densu Delta Ramsar site experiences reduced seasonal flooding, affecting the growth of mangrove species like *Avicennia germinans* and *Rhizophora racemosa*. These mangroves are crucial for fish breeding and carbon sequestration. Similarly, changes in rainfall patterns at the Songor Lagoon have led to salt concentration variability, stressing aquatic life and reducing salt production, a key livelihood activity in the area (Ramsar Convention, 2020; UNEP, 2022).

5.3.3. Flooding

Intense rainfall and flooding events inundate wetlands, altering salinity levels and damaging vegetation. Coastal wetlands like the Sakumo Lagoon face saltwater intrusion during floods, which negatively affects freshwater species such as the African manatee (*Trichechus senegalensis*). Flooding

also increases sedimentation, choking aquatic vegetation and reducing habitat quality for wading birds like herons (*Ardea spp.*) and egrets (*Egretta spp.*) (Ramsar Convention, 2020; EPA, 2021).

5.3.4. Sea Level Rise

Coastal wetlands are particularly vulnerable to rising sea levels, which lead to the submergence of habitats and increased salinity. The Keta Lagoon, one of Ghana's largest coastal wetlands, is experiencing encroachment from the sea, affecting its ecological integrity. Mangrove forests within this wetland are being degraded, reducing their ability to serve as breeding grounds for fish like *Ethmalosa fimbriata* (bonga shad). Rising sea levels also threaten the livelihoods of communities relying on these ecosystems for fishing and salt production (UNFCCC, 2020; MESTI, 2022).

5.3.5. Deforestation and Land Conversion

Human activities such as deforestation and land conversion exacerbate the vulnerabilities of wetlands. At the Muni-Pomadze Lagoon, agricultural expansion and urban development have encroached on wetland areas, reducing their size and functionality. The destruction of surrounding vegetation impacts the habitat of migratory bird species and reduces the ecosystem's ability to filter pollutants and store carbon (EPA, 2021; Ramsar Convention, 2020).

5.3.6. Pollution

Pollution from agricultural runoff, industrial discharges, and urban waste severely impacts wetland biodiversity. In the Sakumo Lagoon, eutrophication from nutrient-rich runoff fosters the growth of invasive aquatic weeds like water hyacinth (*Eichhornia crassipes*), which suffocate native plants and fish. This affects the lagoon's ability to sustain artisanal fisheries, a critical source of income for nearby communities (EPA, 2021; UNEP, 2022).



Table 13. Risks and Vulnerabilities Impacting Wetland Ecosystems: Biodiversity and Community Examples from Ghana

Risks and Vulnerabilities	Impacts	Examples from Wetland Zones and Communities
Rising Temperatures	Accelerates evaporation, reducing water levels and affecting species like tilapia and flamingos.	Keta Lagoon faces reduced water levels, impacting fisheries and migratory bird habitats (EPA, 2021).
Erratic Rainfall Patterns	Disrupts seasonal flooding, affecting mangroves and aquatic species.	Densu Delta experiences reduced seasonal flooding, impacting mangroves and fish breeding grounds (MESTI, 2022).
Flooding	Inundates wetlands, altering salinity and damaging vegetation.	Sakumo Lagoon faces saltwater intrusion, reducing habitat quality for freshwater species (Ramsar Convention, 2020).
Sea Level Rise	Submerges habitats and increases salinity, degrading mangroves and fish breeding grounds.	Keta Lagoon is encroached upon by rising seas, threatening mangrove ecosystems and fisheries (UNFCCC, 2020).
Deforestation and Land Conversion	Reduces wetland size and functionality, affecting biodiversity and ecological services.	Muni-Pomadze Lagoon faces encroachment from agricultural expansion and urban development (Ramsar Convention, 2020).

Pollution	Leads to eutrophication and invasive species growth, harming native biodiversity.	Sakumo Lagoon suffers from invasive aquatic weeds like water hyacinth due to agricultural runoff (UNEP, 2022).
-----------	---	--

Source: Author’s construct (2024)

5.4. Effects of Climate Change Risks on Marine Ecosystems

Ghana’s marine ecosystems are integral to its economic and ecological sustainability, providing critical resources such as fish, crustaceans, and mollusks while supporting livelihoods through fisheries and coastal activities. These ecosystems, spanning the Exclusive Economic Zone (EEZ), continental shelf, and coastal waters, are rich in biodiversity and vital for climate regulation. However, they are increasingly under threat from climate change and anthropogenic activities, such as overfishing, pollution, and habitat degradation.

5.4.1. Rising Sea-Surface Temperatures

Increasing sea-surface temperatures affect marine biodiversity by altering habitats, breeding cycles, and species distribution. For instance, pelagic fish species like sardines (*Sardinella aurita*) and mackerels (*Scomber japonicus*), which are staples for artisanal fisheries, are moving to deeper or cooler waters, reducing fish catch volumes (Fisheries Commission, 2022). Coral reefs, though limited in Ghana, face bleaching events, jeopardizing reef-associated species like parrotfish (*Scarus* spp.) and surgeonfish (*Acanthurus* spp.).

5.4.2. Sea Level Rise

Rising sea levels lead to the submergence of coastal habitats, increasing salinity levels in estuaries and lagoons. This significantly impacts mangroves and seagrasses, which serve as nurseries for fish species like bonga shad



(*Ethmalosa fimbriata*). Communities along the Keta and Ada coastlines are witnessing mangrove degradation, reducing protection against storm surges and affecting fisheries (UNFCCC, 2020).

5.4.3. Overfishing and Habitat Degradation

Overfishing, driven by both artisanal and industrial fishing activities, depletes fish stocks, disrupting marine food webs. The use of destructive fishing methods, such as bottom trawling, has caused habitat destruction on the continental shelf, affecting benthic species like blue crabs (*Callinectes amnicola*) and spiny lobsters (*Panulirus regius*) (EPA, 2021). This degradation is particularly evident in areas near Tema and Sekondi-Takoradi.

5.4.4. Pollution

Marine pollution from oil spills, industrial effluents, and plastic waste severely impacts biodiversity. In areas like Shama and Axim, oil exploration activities have led to hydrocarbon pollution, harming marine life. Microplastics have been found in fish species like sardines, posing health risks to both marine species and humans reliant on these fish for protein (UNEP, 2022).

5.4.5. Ocean Acidification

The absorption of atmospheric CO₂ increases ocean acidity, negatively affecting calcifying organisms such as mollusks and crustaceans. Shellfish populations, crucial for coastal economies, are declining due to weakened shells and reduced survival rates, impacting communities dependent on shellfish harvesting in regions like Elmina and Cape Coast.

5.4.6. Storm Surges and Extreme Weather Events

Increasingly frequent and intense storms disrupt marine ecosystems, damaging coral reefs and mangroves while causing habitat loss. In the

Densu Delta and Sakumo Lagoon, storm surges have led to coastal erosion, endangering the livelihoods of artisanal fishers and displacing coastal communities (Ramsar Convention, 2020).

Table 14. Risks, Vulnerabilities, and Impacts on Marine Ecosystems

Risks and Vulnerabilities	Impacts	Examples from Marine Zones and Communities
Rising Sea-Surface Temperatures	Alters species distribution, reduces fish stocks, and causes coral bleaching.	Pelagic fish like sardines are moving to cooler waters, reducing catch volumes in communities like Axim and Takoradi (Fisheries Commission, 2022).
Sea Level Rise	Submerges coastal habitats, increases salinity, and degrades mangroves.	Mangrove degradation in Keta and Ada reduces storm protection and fish breeding grounds (UNFCCC, 2020).
Overfishing and Habitat Degradation	Depletes fish stocks, disrupts food webs, and damages benthic habitats.	Bottom trawling near Tema affects blue crabs and spiny lobsters (EPA, 2021).
Pollution	Harms marine biodiversity and introduces toxins into the food chain.	Oil spills near Shama harm marine life; microplastics in sardines pose health risks (UNEP, 2022).
Ocean Acidification	Reduces survival rates of calcifying organisms like mollusks and crustaceans.	Decline in shellfish populations impacts harvesters in Elmina and Cape Coast (UNEP, 2022).



Storm Surges and Extreme Weather Events	Damages coral reefs and mangroves, leading to habitat loss and displacement.	Coastal erosion in Sakumo Lagoon affects artisanal fisheries and displaces communities (Ramsar Convention, 2020).
---	--	---

Source: Author's construct (2024)

5.5. Effects of Climate Change Risks on Aquatic Ecosystems

Ghana's aquatic ecosystems, comprising rivers, lakes, and artificial reservoirs, are pivotal for freshwater biodiversity, water supply, irrigation, and energy generation. These ecosystems sustain diverse flora and fauna, support agriculture and fisheries, and play vital roles in cultural and spiritual practices. However, the increasing impacts of climate change, coupled with anthropogenic activities, are undermining their ecological integrity and productivity.

5.5.1. Rising Temperatures

Higher temperatures accelerate evaporation, leading to reduced water levels in rivers and lakes. Lake Volta, the world's largest artificial reservoir, has seen fluctuating water levels, adversely affecting fish species such as *Oreochromis niloticus* (Nile tilapia) and *Heterotis niloticus* (African bonytongue). These changes disrupt fish breeding cycles and reduce fish catches, threatening livelihoods in communities like Akosombo and Kpando (EPA, 2021).

5.5.2. Erratic Rainfall Patterns

Unpredictable rainfall disrupts the hydrological balance of aquatic ecosystems. Rivers such as the Pra, Tano, and Ankobra, which support irrigation and drinking water supply, experience irregular flows, affecting both agricultural productivity and water availability. In the Volta Basin, inconsistent rainfall has reduced inflows into the Akosombo Dam, impacting

hydropower generation and fish populations dependent on consistent water flow (UNFCCC, 2020).

5.5.3. Flooding

Intense rainfall events cause flooding, leading to sedimentation and water quality degradation. The White Volta River frequently experiences flooding, which washes pollutants and sediments into aquatic systems, degrading habitats for fish and aquatic plants. Communities along the riverbanks, such as those in Bawku and Bolgatanga, face loss of farmland and disruption to their water-dependent activities (EPA, 2021).

5.5.4. Drought

Prolonged dry periods reduce water availability, stressing aquatic species and ecosystems. Rivers such as the Densu and Ayensu experience reduced flows during droughts, affecting aquatic biodiversity and communities reliant on these rivers for irrigation and domestic use. The decline in water levels in Lake Bosomtwe, Ghana's only natural lake, is threatening its endemic species, including the cichlid *Tilapia busumana* (UNEP, 2022).

5.5.5. Pollution

Pollution from agricultural runoff, mining activities, and urban waste significantly impacts aquatic ecosystems. Mercury contamination from illegal mining (galamsey) in rivers like the Pra and Ankobra harms aquatic life and poses health risks to communities relying on these rivers for water and fish. The proliferation of water hyacinths (*Eichhornia crassipes*) in polluted waters further depletes oxygen levels, affecting fish populations and water quality (EPA, 2021).

5.5.6. Erosion and Sedimentation



Deforestation and poor land management practices increase erosion, leading to sedimentation in aquatic ecosystems. The Black Volta River suffers from heavy sediment loads, reducing water quality and disrupting aquatic habitats. Communities downstream, such as those in Wa and Tumu, face challenges in accessing clean water for domestic and agricultural use (UNFCCC, 2020).

Table 15. Risks, Vulnerabilities, and Impacts on Aquatic Ecosystems

Risks and Vulnerabilities	Impacts	Examples from Aquatic Zones and Communities
Rising Temperatures	Accelerates evaporation, reducing water levels and affecting fish populations.	Lake Volta experiences fluctuating water levels, disrupting fish breeding cycles in Akosombo and Kpando (EPA, 2021).
Erratic Rainfall Patterns	Disrupts hydrological balance, affecting water availability and biodiversity.	Volta Basin experiences reduced inflows into Akosombo Dam, impacting hydropower and fisheries (UNFCCC, 2020).
Flooding	Increases sedimentation and degrades water quality.	White Volta flooding degrades aquatic habitats and farmland in Bawku and Bolgatanga (EPA, 2021).
Drought	Reduces water availability, stressing aquatic ecosystems.	Lake Bosomtwe faces declining water levels, threatening endemic species like <i>Tilapia busumana</i> (UNEP, 2022).

Pollution	Harms aquatic biodiversity and introduces toxins into the water supply.	Mercury contamination from galamsey in Pra River harms aquatic life and communities reliant on its water (EPA, 2021).
Erosion and Sedimentation	Degrades water quality and disrupts aquatic habitats.	Black Volta suffers from sedimentation, reducing water quality for communities in Wa and Tumu (UNFCCC, 2020).

Source: Author's construct (2024)





CHAPTER 6: PROPOSED ADAPTATION ACTIONS FOR THE BIODIVERSITY AND ECOSYSTEM SECTOR

6.1. Introduction

To safeguard Ghana's rich biodiversity and vital ecosystems from the growing threats of climate change, a robust set of adaptation actions is required. These strategies aim to build ecological resilience, support livelihoods dependent on natural resources, and contribute to sustainable development. Drawing on existing policies, community insights, and global best practices, the following proposed actions are tailored to address the unique vulnerabilities of Ghana's biodiversity and ecosystem sector.

6.2. Restoration and Conservation of Forest Ecosystems

Ghana's forests, comprising wet evergreen, moist deciduous, and dry semi-deciduous types, as well as gallery and swamp forests, are vital for biodiversity, carbon sequestration, and the livelihoods of millions. Reforestation initiatives in degraded areas, such as the Atewa Range Forest Reserve and the Kakum National Park, are critical adaptation actions. Planting indigenous species like *Milicia excelsa* (Odum) and *Khaya ivorensis* (African Mahogany) not only restores ecological balance but also enhances forest-based livelihoods through sustainable timber production and non-timber forest products.

Promoting community-based forest management programs has proven successful in protecting biodiversity and reducing illegal logging. For instance, the Community Resource Management Areas (CREMAs) in the Western and Ashanti Regions empower local communities to monitor forest health, ensuring sustainable use of forest resources. The integration of agroforestry practices, especially in the forest-savannah transition zones, creates a synergy between conservation and agriculture, enhancing soil fertility and providing diversified income sources for farmers.

Tackling illegal mining (galamsey) remains a top priority for forest conservation. In the Eastern and Western Regions, the reclamation of degraded lands affected by galamsey has involved tree planting initiatives and soil restoration techniques. Establishing forest buffer zones, particularly around critical habitats such as the Ankasa Conservation Area, protects wildlife corridors and reduces encroachment.

Swamp and mangrove forests, particularly in the Volta and Greater Accra Regions, benefit from targeted restoration efforts to combat coastal erosion and enhance fish breeding grounds.

This includes the planting of mangrove species like *Rhizophora racemosa* in the Keta Lagoon Complex. Ecotourism promotion in forests such as Kakum, which boasts a canopy walkway and diverse wildlife, serves as a sustainable financing mechanism for conservation efforts while raising awareness about forest preservation.

Additionally, afforestation projects in the savannah regions, focusing on drought-resistant species like *Vitellaria paradoxa* (Shea) and *Adansonia digitata* (Baobab), contribute to combating desertification and improving the resilience of ecosystems and local livelihoods. A detailed summary of these proposed actions, their impacts, and supporting policies is provided in **Table 16**.

Table 16. Tall list of adaptation actions for the Forests Ecosystem



No	Adaptation Actions	Assessment of Impact	Supporting Policies/Laws
1	Reforestation with native and climate-resilient species	Enhances biodiversity, improves carbon sequestration, and supports local livelihoods.	National Climate Change Policy (2015), Forestry Development Master Plan (2016-2036), Green Ghana Initiative
2	Establishment of forest restoration corridors to reconnect fragmented ecosystems	Promotes species migration and genetic diversity while enhancing ecosystem resilience.	National Biodiversity Strategy and Action Plan (2016-2020)
3	Sustainable harvesting of non-timber forest products (NTFPs) such as shea nuts and medicinal plants	Reduces overexploitation and provides alternative income sources for local communities.	Forest and Wildlife Policy (2012), Non-Timber Forest Product Regulations
4	Enhanced monitoring and enforcement to combat illegal logging and mining	Protects critical ecosystems from degradation, maintains biodiversity, and supports local economies.	Forest Protection Act, Timber Resources Management Act, 1998 (Act 547)
5	Promotion of agroforestry practices in forest-fringe communities	Combats land degradation, increases biodiversity, and supports carbon sequestration while improving soil health.	Ghana Climate Smart Agriculture Action Plan, Food and Agriculture Sector Development Policy (FASDEP)

Source: Author's construct 2024

6.3. Protection and Management of Wetland Ecosystems



Wetland ecosystems in Ghana play a crucial role in biodiversity conservation, water regulation, and supporting local livelihoods. Restoring degraded

mangroves and swamp forests, particularly in the Keta Lagoon and Densu Delta, is a priority action. These efforts enhance coastal protection, sequester carbon, and provide critical breeding grounds for fish species. Swamp forest restoration further bolsters biodiversity, protecting against storm surges while maintaining habitats for aquatic and bird species. Additionally, the development of alternative livelihoods, such as aquaculture and wetland-compatible agriculture, reduces pressure on wetlands. For example, fish farming initiatives near the Sakumo Lagoon have provided sustainable income for local communities, contributing to both economic stability and ecosystem health.

Community-led monitoring programs are essential for ensuring the long-term sustainability of wetlands. Empowering local groups, as seen around the Owabi Wildlife Sanctuary, fosters a sense of ownership and encourages the adoption of sustainable practices. Establishing wetland buffer zones around critical areas such as the Muni-Pomadze Lagoon prevents encroachment and habitat degradation, further protecting biodiversity. Another promising approach is the promotion of ecotourism. Guided tours at wetlands like the Songor Lagoon educate visitors on the importance of conservation while generating revenue for local communities. These combined actions contribute to the restoration and sustainable management of Ghana's wetlands. **Table 17** provides a summary of adaptation actions for the wetland ecosystems resilience in Ghana

Table 17: Tall list of adaptation actions for Wetland Ecosystem

No	Adaptation Actions	Assessment of Impact	Supporting Policies/Laws
1	Restore degraded mangroves and swamp forests (e.g., Keta Lagoon, Densu Delta).	Mangrove restoration improves coastal protection, carbon sequestration, and fisheries.	- Ramsar Convention - Wetland Management (Ramsar Sites) Regulation 1999

2	Develop alternative livelihoods such as aquaculture for wetland-dependent communities.	Reduces pressure on wetland resources while promoting sustainable economic growth.	- National Wetland Strategy
3	Enhance community-led wetland monitoring and conservation programs.	Strengthens the long-term sustainability and effective management of wetlands.	- Environmental Protection Agency Act, 1994 - Ramsar Site Management Plans
4	Establish wetland buffer zones to prevent encroachment.	Protects biodiversity-rich wetlands and reduces habitat degradation.	- National Land Policy
5	Promote ecotourism in Ramsar sites to generate income.	Provides sustainable revenue streams while protecting biodiversity.	- National Biodiversity Strategy and Action Plan (2016-2020)
6	Introduce wetland-compatible agriculture, such as cultivation of water-tolerant crops.	Supports food security while maintaining wetland ecosystem integrity.	- Ghana Agricultural Investment Plan (METASIP)
7	Implement floodplain zoning to protect critical wetland habitats.	Prevents infrastructure development that damages wetland ecosystems, ensuring biodiversity protection.	- National Land Use and Spatial Planning Policy

Source: Author's Construct, 2024

6.4. Sustainable Management of Marine Ecosystems

Ghana's marine ecosystems, encompassing its Exclusive Economic Zone, are critical for fisheries, biodiversity, and coastal livelihoods. Establishing Marine Protected Areas (MPAs) safeguards critical habitats and spawning grounds, allowing fish stocks to recover. Protected zones within the EEZ have shown significant promise in preserving marine biodiversity. Seasonal fishing bans during breeding periods also play a vital role in regenerating fish populations, such as sardines (*Sardinella aurita*) and mackerels (*Scomber japonicus*), ensuring the sustainability of fisheries for future generations.

Marine pollution reduction is another critical adaptation action. Coastal waste management initiatives, including beach clean-ups in Accra, have improved water quality and contributed to healthier coral reef systems. Promoting sustainable artisanal fishing practices, such as the adoption of non-destructive nets in Cape Coast, has reduced overfishing and protected juvenile fish populations. Strengthening marine biodiversity monitoring through research and capacity-building initiatives, like those implemented in Tema, has provided valuable data for informed decision-making in marine conservation. These actions collectively address the overexploitation and degradation of Ghana's marine ecosystems while supporting the livelihoods of coastal communities. Table 18 provides a summary of adaptation actions for enhancing resilience in marine ecosystems.



Table 18: Tall list of adaptation actions for Marine Ecosystem

No	Adaptation Actions	Assessment of Impact	Supporting Policies/Laws
1	Establish marine protected areas (MPAs) to safeguard habitats.	Protects spawning and nursery grounds, allowing fish stocks to recover.	- Fisheries Act, 2002 - Ghana Marine Fisheries Management Plan
2	Enforce seasonal fishing bans to allow fish stock regeneration.	Improves long-term fish population stability, supporting coastal livelihoods.	- Fisheries Management Plan
3	Reduce marine pollution through coastal waste management initiatives.	Improves water quality and reduces damage to coral reefs and marine life.	- National Integrated Coastal and Fisheries Initiative
4	Promote sustainable artisanal fishing practices through community-led initiatives.	Reduces overfishing and ensures long-term productivity of marine ecosystems.	- Artisanal Fisheries Development Program
5	Strengthen capacity for marine biodiversity monitoring and research.	Enhances data availability for informed decision-making on marine ecosystem conservation.	- Ghana Climate Change Policy (2013)

6	Implement mangrove replanting along coastal zones to protect marine nurseries.	Enhances nursery habitats for marine species, bolstering fish stocks and ecosystem health.	- Mangrove Restoration Guidelines
7	Develop coastal green infrastructure (e.g., sea walls, dunes) to mitigate storm surges.	Protects coastal communities and marine habitats from climate impacts like rising sea levels.	- Integrated Coastal Zone Management Policy

6.5. Conservation of Aquatic Ecosystems

Aquatic ecosystems, including rivers, lakes, and reservoirs, are vital for biodiversity, irrigation, and water supply in Ghana. Rehabilitating riparian zones along major rivers like the Volta and Pra is a critical adaptation action. These efforts reduce erosion, improve water quality, and support aquatic biodiversity. For instance, riparian restoration in the Northern Region has led to increased fish populations and clearer water, benefiting both ecosystems and local communities.

Managing invasive aquatic species, such as water hyacinths in Lake Volta, is essential for improving water flow and habitat quality. Efforts to control these species have restored aquatic ecosystems and enhanced biodiversity. Integrated watershed management programs are also being implemented to ensure sustainable water availability. The conservation of the Densu River Basin, for example, has mitigated sedimentation, improving water quality and benefiting downstream communities.

Biodiversity-rich artificial reservoirs, like the Akosombo Reservoir, provide habitats for fish and other aquatic species while supporting local livelihoods. Fish sanctuaries in critical riverine habitats, such as those established along the Tano



River, protect breeding grounds and help maintain fish populations. Additionally, promoting ecotourism around lakes and rivers, such as birdwatching at Lake Bosomtwe, generates sustainable income for local communities while fostering an appreciation for aquatic biodiversity. These combined actions ensure the sustainable management and resilience of Ghana's aquatic ecosystems. **Table 19** provides a summary of adaptation actions for enhancing resilience in aquatic ecosystems.

Table 19. Tall list of adaptation actions for Aquatic Ecosystem

No	Adaptation Actions	Assessment of Impact	Supporting Policies/Laws
1	Rehabilitate riparian zones along major rivers like Volta and Pra.	Reduces erosion, enhances water quality, and supports biodiversity.	- National Riparian Buffer Zone Policy
2	Remove invasive aquatic species such as water hyacinths from rivers and lakes.	Prevents ecological disruptions and improves water flow and aquatic habitats.	- Environmental Protection Act
3	Implement watershed management programs.	Protects vital water sources, ensuring sustainable water availability for irrigation and biodiversity.	- Ghana Water Resources Policy
4	Develop biodiversity-rich artificial reservoirs.	Enhances aquatic biodiversity and provides sustainable livelihood opportunities.	- Ghana Irrigation Development Policy

5	Introduce integrated water resource management (IWRM) to optimize water use and conserve aquatic habitats.	Ensures sustainable water use, reduces conflict, and protects critical aquatic ecosystems.	- Ghana Water Resources Commission Act
6	Establish fish sanctuaries in critical riverine habitats to protect breeding grounds.	Maintains fish populations and improves aquatic biodiversity.	- Fisheries Act, 2002
7	Promote ecotourism around lakes and rivers, focusing on biodiversity conservation.	Generates sustainable income while fostering appreciation and protection of aquatic ecosystems.	- National Biodiversity Strategy and Action Plan (2016-2020)





CHAPTER 7: ACTION PLAN FOR THE BIODIVERSITY AND ECOSYSTEM SECTOR

7.1. Introduction

The biodiversity and ecosystem sector is essential to Ghana's sustainable development, underpinning livelihoods, food security, and climate resilience. Despite its importance, this sector faces numerous challenges, including deforestation, wetland degradation, overfishing, and the impacts of climate change. To address these issues, a comprehensive action plan has been developed to ensure the conservation and sustainable management of Ghana's biodiversity and ecosystems. This action plan integrates stakeholder priorities, national policies, and international commitments, such as the Convention on Biological Diversity (CBD), to outline actionable strategies for adaptive management, capacity building, and policy alignment.

The overarching goal of the action plan is to build resilience in Ghana's biodiversity and ecosystem sector through sustainable and inclusive practices. Specific objectives include:

1. Protect and restore critical ecosystems, such as forests, wetlands, and marine habitats, through reforestation, habitat restoration, and species protection initiatives.
2. Equip communities and institutions with the knowledge, tools, and resources to manage ecosystems sustainably under changing climatic conditions.

3. Develop and implement frameworks for the sustainable use of natural resources, ensuring a balance between economic benefits and ecological integrity.
4. Align sectoral policies with biodiversity conservation goals, integrating them into national and local planning frameworks.

7.2. Adaptation Action for the Forestry Sector

The proposed adaptation actions for the forestry sector in Ghana emphasize restoring, protecting, and sustainably managing forest resources to combat the challenges posed by climate change and human activities (**Table 20**). Reforestation and afforestation programs are at the forefront, aiming to restore degraded forest lands in regions such as Ashanti and Western through large-scale tree planting initiatives. These programs prioritize planting native species and establishing robust monitoring systems to ensure the long-term recovery and sustainability of forest ecosystems. The success of these initiatives is assessed by the hectares of forest restored and the subsequent improvement in biodiversity levels.

Sustainable forest management practices are being promoted to address the widespread challenges of overexploitation and degradation, particularly in areas affected by logging and illegal mining, such as the Eastern and Western North regions. These practices involve strict enforcement of forest policies, enhanced regulation of logging activities, and providing training in sustainable harvesting techniques to reduce degradation and ensure ecological balance. By addressing these critical issues, the forestry sector can sustainably meet economic demands while preserving its ecological integrity.

Community forest conservation programs empower local communities in regions such as Volta and Northern to establish and manage forest reserves. These initiatives provide training in biodiversity monitoring and offer incentives to



encourage active participation by community members. Through this approach, local stakeholders are engaged in forest protection, fostering sustainable livelihoods and ensuring that conservation efforts align with community interests and priorities.

To safeguard critical ecosystems, efforts to enhance forest ecosystem services focus on areas such as the Tano Offin watershed, which plays a vital role in water regulation and carbon storage. Payment for Ecosystem Services (PES) schemes and participation in REDD+ initiatives are instrumental in supporting conservation activities. These programs measure success through improvements in water availability and increased carbon sequestration, ensuring that forest ecosystems continue to provide essential services for both environmental health and human well-being.

Education and awareness campaigns are integral to promoting forest conservation across the country. These nationwide initiatives highlight the importance of sustainable forest practices and share success stories from conservation areas such as Kakum.



Table 20. Adaptation Actions for Forestry sub-sector

Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
Reforestation and Afforestation Programs	Restore degraded forests and enhance carbon sequestration.	- Identify degraded forest areas in regions like Ashanti, Western, and Bono for reforestation. - Collaborate with local communities to plant native tree species. - Monitor and evaluate reforestation progress.	- Number of hectares reforested annually. - Improved forest cover in identified regions.	Medium-term	Financial, Human	Forestry Commission	Local Communities, NGOs, Development Partners	



Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
Sustainable Forest Management Practices	Promote the sustainable use of forest resources while ensuring biodiversity conservation.	- Train communities on sustainable harvesting techniques. - Develop and enforce policies to regulate logging and mining activities. - Enhance community participation in forest governance.	- Reduction in illegal logging and mining activities. - Increase in sustainably managed forests.	Long-term	Financial, Technical	Forestry Commission	EPA, MoFA, International Organizations	
Community Forest Conservation Programs	Empower local communities to manage and conserve forests.	- Establish community forest reserves in areas like the Northern and Volta regions. - Train community members on biodiversity monitoring and protection. - Provide incentives for community-led conservation efforts.	- Number of community forest reserves established. - Increase in community participation.	Medium-term	Human, Financial	Forestry Commission	Local NGOs, District Assemblies, Development Agencies	



Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
Forest Ecosystem Services Enhancement	Strengthen the role of forests in providing critical ecosystem services such as water regulation and carbon storage.	- Protect watershed areas like Tano Offin and Ankasa Conservation Area. - Implement Payment for Ecosystem Services (PES) schemes. - Enhance carbon sequestration efforts through REDD+ programs forest governance..	Increase in ecosystem service indicators such as water availability and carbon sequestration.	Long-term	Financial, Technical	Forestry Commission	International Development Partners, EPA, Local Governments	
Community Forest Conservation Programs	Empower local communities to manage and conserve forests.	- Establish community forest reserves in areas like the Northern and Volta regions. - Train community members on biodiversity monitoring and protection. - Provide incentives for community-led conservation efforts.	- Number of community forest reserves established. - Increase in community participation	Medium-term	Human, Financial	Forestry Commission	Local NGOs, District Assemblies, Development Agencies	



Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
Forest Ecosystem Services Enhancement	Strengthen the role of forests in providing critical ecosystem services such as water regulation and carbon storage.	- Protect watershed areas like Tano Offin and Ankasa Conservation Area. - Implement Payment for Ecosystem Services (PES) schemes. - Enhance carbon sequestration efforts through REDD+ programs.	Increase in ecosystem service indicators such as water availability and carbon sequestration.	Long-term	Financial, Technical	Forestry Commission	International Development Partners, EPA, Local Governments	
Forest Education and Awareness Campaigns	Enhance public knowledge and engagement in forest conservation.	- Develop and distribute educational materials on forest conservation - Conduct nationwide campaigns to raise awareness about deforestation impacts. - Highlight conservation success stories through media platforms.	Increase in public awareness and conservation initiatives.	Short-term	Financial, Human	MoE	Forestry Commission, NGOs, Media Organizations	



7.3. Adaptation Action for the Wetland Ecosystem

Ghana's wetland ecosystems, comprising inland, coastal, and Ramsar-designated sites, play a critical role in supporting biodiversity, regulating water systems, and sustaining livelihoods. These wetlands provide essential services, including flood regulation, water purification, carbon sequestration, and fish breeding habitats. Coastal wetlands, such as the Sakumo Lagoon and Densu Delta, are vital for artisanal fisheries and storm protection, while inland wetlands like the Volta River Basin and Lake Bosomtwe sustain agriculture, freshwater biodiversity, and serve as migratory bird habitats. Ramsar sites, including the Keta Lagoon and Muni-Pomadze, are internationally recognized for their ecological importance and support a wide range of flora and fauna.

Despite their significance, wetlands in Ghana face increasing threats from urbanization, pollution, encroachment, and unsustainable resource exploitation. These challenges have led to the degradation of wetland habitats, reduced biodiversity, and impaired ecosystem functionality. To ensure the sustainability of these ecosystems, a strategic and collaborative approach to wetland conservation and management is crucial. This includes fostering community participation, enhancing governance, and implementing targeted restoration and sustainable livelihood initiatives. For a detailed adaptation framework for Ghana's wetlands, refer to the following **Table 21**.



Table 21. Adaptation Actions for Wetland Ecosystems

Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners
Restore and conserve degraded wetlands	Enhance the ecological health and functionality of degraded wetlands	- Identify degraded wetlands for restoration and prioritize interventions based on ecological importance. - Conduct restoration activities such as planting mangroves and removing invasive species. - Promote community-based wetland conservation programs.	- Area (hectares) of wetlands restored. - Increase in biodiversity levels and ecosystem services.	Medium-term	Human, Finance, Technology	EPA	MLNR, NGOs, Local Governments, Ramsar Secretariat
Strengthen wetland management policies	Improve governance and sustainable management of wetland ecosystems	- Develop and enforce wetland-specific regulations. - Integrate wetland conservation into local development planning. - Conduct stakeholder workshops to align wetland management policies with community needs.	- Number of regulations enacted or enforced. - Percentage of wetlands under sustainable management practices.	Medium-term	Finance, Human	EPA	MESTI, MLNR, NDPC, NGOs





Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners
Promote sustainable wetland-based livelihoods	Support communities in utilizing wetland resources sustainably while reducing exploitation pressure	- Train local communities in sustainable wetland-based livelihoods such as ecotourism, fishing, and mangrove harvesting. - Provide financial and technical support for alternative income-generating activities. - Establish markets for wetland-derived products like sustainably harvested fish and non-timber resources.	- Number of community members engaged in sustainable livelihoods. - Reduction in overexploitation of wetland resources.	Medium-term	Medium-term	Finance, Human, Technology	EPA
Develop and expand Ramsar sites	Protect critical wetland ecosystems through international recognition and support	- Identify and propose additional critical wetlands for designation as Ramsar sites. - Improve infrastructure and monitoring systems at existing Ramsar sites. - Conduct community awareness programs on the significance of Ramsar designation and wetland conservation.	- Number of Ramsar sites established or expanded. - Improved conservation outcomes for designated sites.	Long-term	Finance, Technology	EPA	Ramsar Secretariat, MLNR, MESTI, NGOs

Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners
Implement flood management in wetlands	Enhance the resilience of wetlands to flooding and maintain their ecological functionality	- Construct and maintain flood control structures in vulnerable wetland areas. - Restore natural floodplains and riparian zones to enhance flood mitigation. - Conduct hydrological studies to assess and optimize flood management interventions.	- Reduction in flood damage within wetland areas. - Improved ecosystem services related to flood regulation.	Long-term	Finance, Human	EPA	MLNR, NDPC, Local Governments, NGOs
Raise public awareness and education on wetlands	Increase public knowledge and engagement in wetland conservation and sustainable management practices	- Organize educational campaigns and workshops targeting schools, local communities, and policymakers. - Develop and distribute educational materials highlighting the importance of wetlands for biodiversity, flood management, and livelihoods.	- Increased participation in wetland conservation activities. - Improved public understanding of wetland importance.	Short-term	Human, Finance	EPA	NGOs, MESTI, MLNR



Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners
Monitor wetland health and biodiversity	Establish a robust monitoring framework to track changes in wetland health and biodiversity	- Develop indicators for wetland health and biodiversity. - Establish monitoring stations and conduct periodic assessments of wetland ecosystems. Use remote sensing technologies to assess changes in wetland cover and functionality.	- Regular wetland health reports published. - Detection and mitigation of adverse trends in wetland ecosystems.	Long-term	Technology, Finance	EPA	Research Institutions, NDPC, NGOs



7.4. Adaptation Action for the Marine Ecosystem

Ghana's marine ecosystems, spanning its Exclusive Economic Zone (EEZ), are vital to biodiversity conservation, food security, and coastal livelihoods. These ecosystems support diverse marine species, including pelagic fish such as sardines (*Sardinella aurita*) and mackerels (*Scomber japonicus*), benthic species like blue crabs (*Callinectes amnicola*), and coral reef species such as parrotfish (*Scarus* spp.). They also provide essential ecosystem services such as fish breeding, carbon sequestration, and coastal protection. However, overfishing, illegal fishing practices, pollution, and rising sea temperatures have significantly impacted marine biodiversity and ecosystem health, leading to declining fish stocks and habitat degradation.

To address these challenges, a comprehensive marine adaptation action plan is essential, focusing on sustainable fishing practices, marine habitat restoration, and strengthening governance frameworks. The plan should also promote community engagement, scientific research, and innovative solutions such as aquaculture and marine protected areas. **Table 22** is a proposed action plan for Ghana's marine ecosystem conservation and adaptation:



Table 22. Marine Ecosystem Adaptation Action Plan

Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
Establish Marine Protected Areas (MPAs)	Conserve marine biodiversity and restore degraded habitats	Identify critical marine habitats for protection.	Number of MPAs established and operational	Medium-term	Human, Finance	Fisheries Commission	EPA, MESTI, NGOs, Coastal Communities	
		Conduct stakeholder consultations to ensure community buy-in and compliance.	Percentage of stakeholders actively participating in MPA management.					
		Implement monitoring and enforcement systems to protect MPAs from illegal fishing and pollution.	Reduced incidences of illegal activities within MPAs.					
Promote Sustainable Fishing Practices	Reduce overfishing and maintain fish stock levels	Train fishers on sustainable fishing techniques and provide alternative livelihoods to reduce pressure on marine resources.	Number of fishers trained and adopting sustainable practices.	Short-term	Human, Finance, Technology	Fisheries Commission	FAO, NGOs, Community-Based Fisheries Management Committees (CBFMCs), Private Sector	



Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
		Enforce laws against illegal, unreported, and unregulated (IUU) fishing.	Reduced IUU fishing activities as reported by monitoring agencies.					
		Promote the use of selective fishing gear to minimize bycatch and ensure sustainable harvesting.	Increased use of selective fishing gear among artisanal and industrial fishers.					
Restore Degraded Coral Reefs	Enhance marine biodiversity and support fish breeding and nursery grounds	Conduct baseline studies to identify priority areas for coral restoration.	Number of hectares of coral reefs restored.	Medium-term	Human, Technology	Fisheries Commission	Research Institutions, EPA, NGOs, Coastal Communities	
		Engage local communities in coral restoration programs to promote stewardship and ownership.	Number of community members involved in coral restoration initiatives.					



Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
		Implement artificial reef structures to accelerate restoration and support marine life.	Increased diversity and abundance of marine species in restored areas.					



Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
Develop and Expand Aquaculture	Reduce pressure on wild fish stocks and provide sustainable food sources	Provide financial and technical support for small-scale aquaculture ventures.	Number of aquaculture farms established and operational.	Short-term	Finance, Technology	Ministry of Fisheries and Aquaculture Development (MoFAD)	FAO, Private Sector, Community Cooperatives, Research Institutions	
		Train fish farmers in best aquaculture practices to ensure environmental sustainability.	Percentage of fish farmers adopting sustainable aquaculture practices.					
		Develop market linkages for aquaculture products to enhance profitability and sustainability.	Increased income levels for aquaculture operators.					
Strengthen Marine Pollution Control	Protect marine ecosystems from the adverse effects of pollution	Conduct public awareness campaigns on marine pollution and its impacts.	Increased public awareness and reduction in marine litter.	Medium-term	Human, Finance	EPA	Fisheries Commission, Coastal Communities, NGOs	



Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
		Strengthen enforcement of regulations against marine pollution, particularly from plastics and industrial discharge.	Reduction in plastic waste and industrial pollutants in marine environments.					
		Establish waste collection and recycling programs in coastal communities to prevent waste from entering the marine environment.	Number of functional waste collection and recycling programs in coastal areas.					



7.5. Adaptation Action for the Aquatic Ecosystem

Ghana's aquatic ecosystems, comprising major rivers, lakes, and artificial reservoirs, are essential for freshwater biodiversity, agriculture, and local livelihoods (**Table 23**). Rivers such as the Volta, Pra, Tano, and Ankobra support endemic species like Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*), while Lake Volta, the largest man-made lake in the world, is critical for fisheries, hydropower generation, and irrigation. However, these ecosystems face challenges including pollution from agricultural runoff, siltation due to deforestation, and reduced water flow caused by climate change. Adaptation actions aim to restore water quality, enhance fish populations, and ensure sustainable water use to maintain ecosystem services and biodiversity.



Table 23. Adaptation Action Plan for the Aquatic Ecosystem

Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
Improve water quality in rivers and lakes	Restore freshwater ecosystems and enhance biodiversity	Implement riparian buffer zones along major rivers	Number of kilometers of riparian zones restored	Medium-term	Human, Finance, Tech	EPA	WRC, NGOs, District Assemblies	
		Conduct community-led water quality monitoring	Number of community monitoring groups established	Medium-term	Human, Finance	WRC	NGOs, Universities	
Enhance sustainable fishery management practices	Sustain freshwater fish populations and livelihoods	Introduce fishery co-management systems in communities	Percentage of communities adopting fishery co-management systems	Medium-term	Finance, Tech	Fisheries Comm.	MoFA, District Assemblies	
		Ban destructive fishing methods such as dynamite and poisoning	Number of enforcement actions against destructive fishing methods	Short-term	Human, Finance	Fisheries Comm.	Local Authorities, NGOs	



Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
Restore aquatic habitats	Increase aquatic biodiversity and ecosystem resilience	Rehabilitate degraded wetlands connected to rivers and reservoirs	Number of hectares of wetlands rehabilitated	Long-term	Finance, Tech	EPA	NGOs, District Assemblies	
		Install fish passes and ladders to facilitate fish migration across dams and barriers	Number of fish passes installed	Long-term	Human, Tech	WRC	District Assemblies, NGOs	
Promote sustainable use of artificial reservoirs	Optimize reservoirs for biodiversity, livelihoods, and water management	Develop aquaculture systems with native fish species to reduce pressure on natural populations	Number of aquaculture systems established	Medium-term	FinanceTech	MoFA	Fisheries Comm., Private Sector	
		Train local communities on integrated water resource management	Number of community training sessions conducted	Medium-term	Human, Finance	WRC	NGOs, Universities	



Adaptation Actions	Objectives	Action Steps	Indicators of Success	Time Frame	Resources	Lead	Implementing Partners	Estimated Cost
Combat water pollution	Reduce contamination of aquatic ecosystems	Develop wastewater treatment systems for agricultural and industrial runoff	Number of functional wastewater treatment systems	Long-term	Finance, Tech	EPA	Private Sector, NGOs	
		Educate communities on the impacts of pollution and promote eco-friendly practices	Number of awareness campaigns conducted	Short-term	Human, Finance	EPA	NGOs, Local Authorities	





CHAPTER 8: POLICY AND INSTITUTIONAL FRAMEWORK FOR THE BIODIVERSITY AND ECOSYSTEM SECTOR

8.1. Introduction

Ghana's biodiversity and ecosystem sector is vital to the country's socio-economic and environmental sustainability, offering critical ecosystem services such as carbon sequestration, water regulation, and biodiversity conservation. The sector faces growing challenges from climate change, deforestation, pollution, and land-use changes, which threaten its health and resilience. To address these challenges, a robust policy and institutional framework has been established, rooted in national development goals and aligned with global commitments, including the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD). This framework seeks to integrate climate adaptation and mitigation strategies into biodiversity management, ensuring that ecosystems and the communities that depend on them are protected and can thrive amidst evolving environmental pressures. Through coordinated efforts, innovative financing, and inclusive governance, Ghana aims to safeguard its rich biodiversity and ensure sustainable ecosystem management for current and future generation

8.2. Policy Framework for Biodiversity and Ecosystem Sector

Ghana's biodiversity and ecosystem sector is underpinned by a comprehensive legal and policy framework that addresses climate change impacts, ecosystem degradation, and biodiversity conservation. As a signatory to international agreements such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD), Ghana has developed policies that integrate adaptation and mitigation strategies with sustainable development.

The Ghana National Climate Change Policy (NCCP) (2013) serves as a cornerstone document, emphasizing climate resilience across sectors, including biodiversity and ecosystems. Similarly, the National Climate Change Adaptation Strategy (NCCAS) (2012) outlines specific measures to safeguard ecosystems against climate-related vulnerabilities. These policies, coupled with Ghana's Revised Nationally Determined Contributions (NDCs) (2021), establish a foundation for integrating biodiversity conservation into national development agendas.

In addition, sector-specific policies such as the National Forest Policy (2012) and Wetlands Management Strategy (2007) emphasize the sustainable use and protection of natural resources. Gender-sensitive frameworks, including the National Gender Policy (2015), ensure inclusivity in ecosystem management and climate adaptation efforts. These frameworks collectively guide the implementation of Ghana's biodiversity and ecosystem adaptation plans, aligning with global goals and national priorities (**Table 24**).



Table 24. Policy Framework for Biodiversity and Ecosystem Sector in Ghana

Year	Policy	Aim of the Policy	Reference to Climate Change	Reference to Adaptation	Reference to Biodiversity	Reference to Gender
2013	Ghana National Climate Change Policy (NCCP)	Provides strategic direction for addressing climate change and sustainable development	Acknowledges climate change's impacts on biodiversity and ecosystems, calling for integrated responses.	Promotes adaptive strategies to enhance resilience in vulnerable ecosystems.	Recognizes biodiversity as critical for climate resilience and sustainable development.	Calls for gender-sensitive approaches to climate adaptation in biodiversity sectors.
2012	National Climate Change Adaptation Strategy (NCCAS)	Enhances national resilience to climate impacts through comprehensive adaptation strategies.	Outlines sectoral impacts of climate change, including on biodiversity and ecosystems.	Provides measures to reduce vulnerabilities in ecosystems and enhance their adaptive capacity.	Highlights biodiversity conservation as vital for ecosystem-based adaptation strategies.	Promotes gender-responsive adaptation measures in ecosystem management.
2021	Ghana Revised Nationally Determined Contributions (NDCs)	Outlines commitments to reducing emissions and enhancing resilience.	Emphasizes the role of ecosystems in climate mitigation and adaptation.	Integrates ecosystem-based approaches into national adaptation actions.	Identifies ecosystem restoration and protection as key adaptation priorities.	Acknowledges the need for gender inclusion in climate action planning and implementation.
2012	National Forest Policy	Promotes sustainable management and conservation of forest resources for socio-economic development	Recognizes forests' role in carbon sequestration and mitigating climate change impacts.	Advocates for sustainable forest management as an adaptive measure to climate impacts.	Prioritizes forest biodiversity as essential for ecosystem health and resilience.	Ensures equitable access to forest resources and decision-making for women and marginalized groups.
2007	Wetlands Management Strategy	Conserves and sustainably manages wetlands for biodiversity and livelihoods	Highlights wetlands' importance in climate regulation and flood mitigation.	Promotes wetland restoration as a nature-based adaptation strategy.	Identifies critical wetland habitats and species for targeted conservation efforts.	Encourages community participation, including women, in wetland management and conservation.



2015	National Gender Policy	Mainstreams gender concerns into national development, including biodiversity management.	Recognizes the differential impacts of climate change on men and women.	Supports gender-inclusive adaptation planning and implementation.	Promotes equitable access to biodiversity resources and benefits for men and women.	Focuses on reducing gender disparities in resource management and decision-making.
2016	National Biodiversity Strategy and Action Plan (NBSAP)	Protects and sustainably manages biodiversity for national development	Addresses biodiversity's vulnerability to climate change impacts.	Advocates for ecosystem restoration and species conservation to enhance adaptive capacity.	Identifies key biodiversity hotspots and outlines actions for their conservation.	Ensures that women and marginalized groups are included in biodiversity management efforts.
1994	Environmental Protection Agency Act	Establishes the EPA as the body responsible for environmental management and protection.	Supports climate change mitigation and adaptation efforts through regulatory measures.	Provides a framework for integrating adaptation into environmental policies and programs.	Recognizes the need to protect ecosystems from degradation and pollution.	Calls for inclusive policies to address environmental challenges, benefiting all demographic groups equitably.



8.3. Institutional Arrangements for the Implementation of the Sectoral Plan

The successful implementation of Ghana's biodiversity and ecosystem adaptation plan depends on the collaboration and coordination of various government ministries, agencies, and non-governmental organizations (NGOs). Each institution plays a critical role in ensuring that climate change adaptation strategies are effectively integrated into biodiversity and ecosystem management policies. Table 25 outlines the institutional mandates and their roles in implementing the sectoral plan.

Table 25. Institutional Arrangements for the Biodiversity and Ecosystem Sector Plan

SN	Name of Institution	Mandate
1	Ministry of Environment, Science, Technology, and Innovation (MESTI)	- Leads and coordinates the National Adaptation Plan (NAP) process to ensure biodiversity and ecosystem considerations are integrated into national climate policies and strategies. - Oversees the formulation of climate change and environmental policies, ensuring that biodiversity-related adaptation is embedded in broader national development agendas. - Facilitates cross-sectoral collaboration, bridging efforts between agriculture, forestry, water resources, and health.

2	Environmental Protection Agency (EPA)	- Acts as the technical authority on environmental issues, providing expertise on ecosystem-based adaptation and biodiversity conservation. - Conducts environmental assessments for proposed projects, ensuring their alignment with climate resilience goals. - Implements NAP projects funded by the Green Climate Fund (GCF) and other international bodies. - Develops regulations to safeguard Ghana's wetlands, forests, and aquatic ecosystems from the impacts of pollution and overexploitation. - Monitors the effectiveness of biodiversity adaptation strategies and supports research on emerging challenges and solutions.
3	Ministry of Lands and Natural Resources (MLNR)	- Provides leadership in the sustainable management of land, forests, and wildlife, ensuring their conservation and equitable utilization. - Ensures that land tenure systems promote security, particularly for women and vulnerable communities, enabling investments in ecosystem restoration and biodiversity conservation. - Oversees forest management policies, emphasizing the mitigation of deforestation and illegal mining impacts. - Coordinates with international partners to align local biodiversity policies with global standards and frameworks, such as the Convention on Biological Diversity (CBD).



4	Forestry Commission	• Manages Ghana's forest resources, implementing policies that promote reforestation, afforestation, and the sustainable harvesting of timber and non-timber forest products. • Oversees the conservation of biodiversity in protected areas, ensuring that forest reserves and wildlife sanctuaries maintain their ecological integrity. • Conducts awareness programs to educate communities on the importance of forest ecosystems and their role in mitigating climate change impacts. • Develops partnerships with private sector stakeholders to promote green investments in forestry and biodiversity conservation projects.
5	Ministry of Finance (MoF)	• Mobilizes domestic and international financial resources for biodiversity adaptation programs, including leveraging climate adaptation funds. • Ensures that climate and biodiversity financing are integrated into national budgets, enabling sustainable funding for long-term adaptation initiatives. • Tracks financial inflows for biodiversity conservation and ecosystem restoration projects, ensuring transparency and accountability. • Supports innovative financing mechanisms such as green bonds and public-private partnerships to enhance investment in biodiversity and ecosystems.

6	Ministry of Local Government, Decentralization, and Rural Development (MLGDRD)	• Facilitates the integration of biodiversity-focused adaptation into Metropolitan, Municipal, and District Assemblies (MMDAs) planning processes. • Promotes community-based approaches to ecosystem restoration, empowering local populations to participate in decision-making. • Enhances local capacity to manage climate risks through targeted training and resource allocation. • Fosters partnerships between local governments, traditional authorities, and civil society organizations to address biodiversity challenges.
7	Ministry of Fisheries and Aquaculture Development (MoFAD)	• Ensures the sustainable management of Ghana's coastal and marine biodiversity, combating illegal, unreported, and unregulated (IUU) fishing. • Promotes mangrove restoration and protection as part of ecosystem-based adaptation strategies. • Provides technical support to communities engaged in fisheries and aquaculture, enhancing their capacity to adapt to changing climate conditions. • Facilitates research and policy formulation to address biodiversity loss in marine and coastal areas.



8	Ministry of Water Resources and Sanitation (MWRS)	- Develops policies and programs for the sustainable management of water resources, with a focus on safeguarding wetland and aquatic ecosystems. - Promotes practices to minimize water pollution, ensuring that rivers, lakes, and reservoirs maintain their ecological balance. - Facilitates the construction and maintenance of infrastructure to support sustainable water use and conservation. - Supports integrated water resource management (IWRM) strategies to address the impacts of climate change on aquatic biodiversity.
9	Ministry of Gender, Children, and Social Protection (MoGCSP)	- Ensures that gender-sensitive approaches are integrated into biodiversity adaptation policies and programs, addressing disparities in resource access and participation. - Advocates for the inclusion of women and marginalized groups in decision-making processes related to ecosystem management. - Provides targeted training and resources to enhance the resilience of women and children to biodiversity-related climate impacts.

10	National Development Planning Commission (NDPC)	- Oversees the incorporation of biodiversity adaptation actions into national and local development plans. - Coordinates efforts to align Ghana's biodiversity policies with international frameworks such as the Sustainable Development Goals (SDGs) and the African Union Agenda 2063. - Tracks progress and evaluates the effectiveness of adaptation measures, using data-driven approaches to inform policy adjustments.
11	Ghana Meteorological Agency (GMet)	- Provides real-time weather and climate data to support ecosystem management and biodiversity conservation efforts. - Enhances the capacity of stakeholders to utilize climate information for decision-making in biodiversity planning. - Collaborates with other agencies to integrate weather and climate forecasts into ecosystem-based adaptation strategies.
12	Wildlife Division of Forestry Commission	- Manages Ghana's wildlife resources, ensuring that protected areas are effectively conserved and managed. - Implements measures to mitigate the impacts of climate change on wildlife habitats and species, particularly those most vulnerable to rising temperatures and habitat loss. - Conducts research and monitoring programs to assess the state of biodiversity in protected areas.



13	Water Resources Commission	- Ensures the equitable allocation and sustainable use of water resources, prioritizing the needs of biodiversity and aquatic ecosystems. - Develops policies to address water-related challenges such as pollution, invasive species, and sedimentation in aquatic habitats. - Facilitates stakeholder engagement in the conservation of critical water resources.
----	----------------------------	---

8.4. Gender Considerations for the Biodiversity and Ecosystem Sector

The effective conservation and sustainable management of biodiversity and ecosystems in Ghana require integrating gender-sensitive approaches. Men and women have distinct roles, responsibilities, and dependencies on ecosystems, which must be acknowledged to develop inclusive strategies that foster resilience and sustainability.

8.4.1. Gendered Roles in Ecosystem Use

In Ghana, gender roles significantly influence how individuals interact with ecosystems:

- **Forests:** Women rely on forests for non-timber products like firewood, medicinal plants, and fruits, while men are involved in timber harvesting and cash crop farming.
- **Wetlands:** Women engage in fish processing and gathering mangrove products, while men typically dominate fishing activities.

- **Marine and Aquatic Ecosystems:** Men undertake fishing, whereas women are central to post-harvest activities like processing and marketing.

8.4.2. Key Vulnerabilities of Women

Women are disproportionately affected by ecosystem degradation and climate change due to limited access to resources, financial capital, and decision-making opportunities. For example:

- The depletion of mangroves in Keta Lagoon impacts women who depend on these ecosystems for crab harvesting and firewood.
- Agricultural encroachment on wetlands reduces opportunities for women engaged in small-scale aquaculture.

8.4.3. Barriers to Gender Equality in Biodiversity Management

- **Limited Resource Access:** Women often lack ownership of land and control over natural resources.
- **Underrepresentation in Leadership:** Women are frequently excluded from decision-making processes related to biodiversity management.
- **Education and Training Gaps:** Limited access to technical education hinders women's ability to adopt sustainable practices.
- **Cultural Norms:** Gender norms restrict women's mobility and participation in community resource management.



8.4.4. Institutions and Organizations Supporting Gender and Biodiversity

To address these challenges, partnerships with institutions and organizations are essential:

- **Ministry of Gender, Children, and Social Protection (MoGCSP):** Advocates for gender equality in policies related to ecosystem management.
- **Environmental Protection Agency (EPA):** Ensures women's inclusion in biodiversity conservation projects.
- **Ministry of Lands and Natural Resources (MLNR):** Promotes gender-responsive land tenure reforms.
- Non-Governmental Organizations (NGOs):
 - o **CARE International:** Supports women-led climate adaptation initiatives.
 - o **Oxfam:** Implements community-based biodiversity projects.
 - o **Friends of the Earth Ghana:** Promotes gender-inclusive environmental education.

8.4.5. Gender-Sensitive Adaptation Actions

1. **Empowering Women in Decision-Making** Women should be represented in community-based resource management committees and biodiversity councils. For example, the Ghana Forest Plantation Development Strategy can include gender quotas to ensure active participation.

2. **Enhancing Resource Access** Microfinance programs and land tenure reforms can improve women's access to land and financial capital, enabling them to participate in sustainable ecosystem restoration.
3. **Capacity Building and Education** Targeted training programs on sustainable practices, such as mangrove restoration, eco-tourism, and aquaculture, can empower women to diversify livelihoods while conserving biodiversity.
4. **Promoting Alternative Livelihoods** Initiatives like the "Village Savings and Loans Associations" provide financial support for women to engage in eco-friendly enterprises, reducing dependency on degrading ecosystems.
5. **Monitoring and Evaluation** Gender-responsive monitoring frameworks should assess:
 - o Women's participation in biodiversity initiatives.
 - o Access to training and resources.
 - o Community perceptions of women's roles in conservation.

8.4.6. Examples of Gender-Responsive Initiatives

- **Mangrove Restoration in Keta Lagoon:** Women-led groups replant mangroves to restore biodiversity and sustain livelihoods.



- **Community-Based Fisheries in Volta Region:** Empowering women in fisheries management ensures sustainable practices.
- **Eco-Tourism in Mole National Park:** Training women as tour guides and artisans diversifies income sources while preserving ecosystems.

8.5. Funding Arrangements for the Sector Plan

The successful implementation of the Biodiversity and Ecosystem Sector Plan requires substantial and sustained financial investment. This funding can be mobilized from domestic resources, international donors, development partners, private sector stakeholders, and innovative financing mechanisms. Below is a detailed outline of potential funding arrangements, supported by examples.

8.5.1. Funding Sources and Mechanisms

1. **Government Budget Allocations** Ministries, departments, and agencies should prioritize biodiversity and ecosystem-related projects in their annual budgets. For example:
 - o The Ministry of Environment, Science, Technology, and Innovation (MESTI) could allocate funds for mangrove restoration projects under the National Climate Change Policy (NCCP).
 - o The Ministry of Lands and Natural Resources (MLNR) could prioritize reforestation in degraded forest zones like the Atiwa Range.
2. **International Donor Support** Development partners and international organizations provide significant funding for biodiversity conservation. Examples include:
 - o The Green Climate Fund (GCF) supporting wetland restoration projects.
 - o The United Nations Development Programme (UNDP) funding climate-resilient agriculture in wetland areas.
3. **Public-Private Partnerships (PPPs)** Collaborations between the government and private sector can drive investment in sustainable ecosystem management. Examples include:
 - o Private sector investment in eco-tourism initiatives in Mole National Park.
 - o Corporate sponsorship of mangrove restoration in Keta Lagoon under corporate social responsibility (CSR) programs.
4. **Climate Adaptation Funds** International adaptation funds like the Adaptation Fund and the Global Environment Facility (GEF) can support climate-resilient biodiversity initiatives. For instance:
 - o The Adaptation Fund financing coastal wetland protection in the Volta Region.
5. **Green Bonds** Issuing green bonds can attract investment in large-scale ecosystem restoration projects. For example:



- o Funding reforestation and watershed protection in the Ashanti Region through green bonds.

6. **Community-Based Financing** Village Savings and Loans Associations (VSLAs) and cooperative groups can mobilize resources for small-scale biodiversity projects at the community level. For example:

- o Community-led tree planting initiatives in the Bono East Region.

Green Bonds	Issuance of sustainability-focused bonds	Financing reforestation in degraded forests like the Atiwa Range	Ministry of Finance, MLNR
Community-Based Financing	VSLAs, cooperatives	Community-led reforestation projects in Northern Ghana	Community-based organizations, NGOs

8.5.2. Monitoring and Reporting

To ensure accountability and transparency:

- **Monitoring Frameworks:** Develop frameworks to track the utilization and impact of funds, ensuring alignment with sector objectives.
- **Periodic Audits:** Conduct regular financial audits of funded projects.
- **Public Reporting:** Publish annual progress reports to build stakeholder confidence.

These funding arrangements, when effectively coordinated and monitored, will ensure the successful implementation of the Biodiversity and Ecosystem Sector Plan while promoting sustainability and resilience across Ghana.

8.6. Anticipated Implemented Challenges and Proposed Solutions

8.6.1. Inadequate Financial and Logistical Resources

A primary challenge in implementing the Biodiversity and Ecosystem Sector Action Plan is the insufficiency of funding and logistical support. Reliance on external donor contributions has often resulted in delays or

Table 26. Summary of funding arrangements and examples

Funding Source	Mechanism	Example Projects	Key Institutions
Government Budget Allocations	Sector ministry budgets	Mangrove restoration in the Densu Delta by MESTI and MLNR	MESTI, MLNR, MoF
International Donor Support	Grants, technical assistance	Wetland protection projects funded by UNDP in the Sakumo Lagoon	UNDP, GCF, FAO
Public-Private Partnerships	Joint government-private investments	Eco-tourism infrastructure development in Mole National Park	EPA, Ghana Tourism Authority, private sector
Climate Adaptation Funds	Grants and concessional loans	Coastal resilience programs funded by the Adaptation Fund in Keta Lagoon	Adaptation Fund, GEF, MLGRD



incomplete programs, underscoring the need for more sustainable financial mechanisms. To mitigate this, Ghana must institutionalize biodiversity financing within its national fiscal planning. This can be achieved by creating budgetary allocations for biodiversity projects and adopting innovative funding mechanisms like green bonds, environmental taxes, and carbon trading. Public-private partnerships (PPPs) can be an effective way to attract private sector investment. Additionally, tapping into global funds such as the Green Climate Fund (GCF) and Global Environment Facility (GEF) can provide much-needed financial backing. Regular financial audits and transparent reporting can build confidence among stakeholders and sustain funding momentum.

8.6.2. Human Resource and Capacity Deficits

The implementation of biodiversity and ecosystem initiatives is hampered by limited technical expertise and inadequate institutional capacity, particularly at the district and regional levels. Local stakeholders often lack the requisite knowledge and tools to manage biodiversity challenges effectively. Capacity-building efforts are therefore critical and should focus on technical training programs, hands-on workshops, and the dissemination of practical resources. Collaborating with research institutions like the University of Ghana and technical agencies such as the Forestry Commission can enhance the relevance and quality of training. Mentorship programs with experienced conservation practitioners and international knowledge exchange initiatives can further strengthen the human resource base. Prioritizing local-level engagement will ensure that these efforts resonate with community realities.

8.6.3. Weak Political Commitment

Inconsistent policy implementation and shifting governmental priorities often hinder the sustained execution of action plans. To overcome this, the Government of Ghana must demonstrate a strong commitment by embedding biodiversity and ecosystem plans within its overarching development strategies, such as the National Medium-Term Development Policy Framework. Transparent accountability systems, resource allocation in national budgets, and regular progress reviews are essential to maintain momentum. High-level governmental support, including parliamentary oversight, can ensure that biodiversity remains a national priority. Civil society organizations and international partners must also be involved to advocate for sustained political will and inclusive governance frameworks.

8.6.4. Institutional Fragmentation and Coordination Issues

Fragmented institutional mandates and poor inter-agency communication significantly impede the implementation of ecosystem-related policies. Overlapping roles and a lack of clearly defined responsibilities often lead to inefficiencies. Addressing this requires clear delineation of institutional roles, strengthening inter-agency collaboration, and establishing regular coordination platforms. Monthly meetings among key stakeholders, such as the Ministry of Lands and Natural Resources (MLNR), the Environmental Protection Agency (EPA), and the Ministry of Environment, Science, Technology, and Innovation (MESTI), can facilitate better alignment of goals and activities. Streamlining regulations across sectors will also help create a unified policy landscape to support ecosystem sustainability.



Table 27. Summary of challenges and proposed solutions

Challenge	Proposed Solution	Examples
Financial and Logistical Resources	- Allocate dedicated funds within the national budget for biodiversity projects. - Introduce mechanisms like carbon credits and green bonds. - Leverage international funding (e.g., GCF).	- Establishing a fund to support wetland restoration projects in Sakumo Lagoon. - Financing mangrove reforestation through green bond initiatives.
Human Resource and Capacity Deficits	- Conduct training workshops for local officials and community members. - Foster partnerships with academic and research institutions. - Launch mentorship and exchange programs.	- Training district staff on wetland management in collaboration with KNUST. - Partnering with international organizations for capacity-building initiatives.

Weak Political Commitment	- Embed action plans in national development policies. - Introduce regular progress monitoring and public reporting. - Strengthen advocacy for biodiversity issues.	- Parliamentary reviews of progress on Ramsar site protection. - Ensuring biodiversity is a standing agenda item in the National Development Planning Commission.
Institutional Fragmentation	- Clarify institutional mandates and responsibilities. - Organize regular inter agency coordination meetings. - Align sectoral policies and regulations.	• Monthly coordination meetings between EPA, MLNR, and MESTI to align efforts on forest conservation. • Developing a unified biodiversity strategy.

8.7. Framework for Adaptation, Monitoring and Evaluation

A robust Monitoring and Evaluation (M&E) framework is essential to ensure the effective implementation, assessment, and refinement of adaptation strategies within Ghana's biodiversity and ecosystem sector. The framework is designed to track progress, evaluate the impact of interventions, and facilitate learning for continuous improvement. Its objectives include monitoring the implementation of adaptation actions, assessing their effectiveness in enhancing ecosystem resilience and biodiversity conservation, and generating insights to refine future strategies.

The M&E framework is structured around several key components. Indicators and metrics play a central role and must be Specific, Measurable, Achievable, Relevant, and Time-bound (SMART). Examples include the number of hectares



of degraded forests restored, population trends of key species in protected areas, and the proportion of wetlands sustainably managed. Baseline assessments are crucial for establishing reference points, such as evaluating mangrove cover in coastal wetlands or biodiversity richness in priority forest reserves like Ankasa Conservation Area.

Data collection and management involve diverse tools, including satellite imagery, ecological surveys, and participatory monitoring by local communities. For instance, satellite imagery can track deforestation trends, while community-led biodiversity assessments can provide critical insights into the health of ecosystems like Ramsar sites. Regular reporting ensures transparency and accountability, with institutions producing biannual or annual updates on key adaptation actions, lessons learned, and recommendations for improvement.

Evaluation processes include mid-term reviews to assess ongoing interventions and impact assessments to measure long-term ecological, economic, and social benefits. Stakeholder feedback is a critical component, involving communities, policymakers, and conservation practitioners to refine and enhance adaptation strategies. For example, workshops in Sakumo Lagoon could gather community input on wetland management plans.

Institutional arrangements for implementing the M&E framework are equally important. The Environmental Protection Agency (EPA) leads the development of M&E tools and oversees national reporting on biodiversity actions. The Forestry Commission (FC) monitors forest ecosystems and supports community engagement, while the Ministry of Environment, Science, Technology, and Innovation (MESTI) provides strategic oversight and coordination. Additionally, the Ghana Statistical Service (GSS) ensures the integration of biodiversity data into national statistical reports, and academic institutions and NGOs contribute research, technical expertise, and data collection.





CHAPTER 9: CONCLUSION AND THE WAY FORWARD

9.1. Summary

Biodiversity and ecosystems are fundamental to Ghana's environmental integrity, socio-economic development, and cultural heritage. They underpin critical services such as food security, water purification, carbon sequestration, and climate regulation. However, these vital systems are increasingly threatened by climate change, unsustainable land use practices, pollution, and overexploitation of resources. The National Adaptation Action Plan for the Biodiversity and Ecosystem Sector serves as a strategic response to these challenges, providing a detailed roadmap to enhance ecosystem resilience, protect biodiversity, and support sustainable livelihoods.

The plan identifies the pressing risks and vulnerabilities affecting Ghana's biodiversity and ecosystems, including deforestation, wetland degradation, marine pollution, and the impacts of rising temperatures and erratic rainfall. Through a combination of policy interventions, community-based initiatives, and ecosystem-based adaptation strategies, the plan emphasizes the need for sustainable management and restoration of ecosystems. It also recognizes the importance of integrating traditional ecological knowledge with modern conservation practices to achieve long-term resilience.

The implementation of this plan requires a concerted effort from all stakeholders, including governmental institutions, civil society, private sector actors, and local communities. It highlights the role of nature-based solutions such as reforestation, mangrove restoration, and sustainable fisheries management to mitigate climate impacts while enhancing ecosystem health. Further, the plan underscores the critical role of gender-sensitive approaches in biodiversity conservation, acknowledging that women, particularly in rural areas, are disproportionately

affected by climate change and ecosystem degradation. By empowering women and marginalized groups, the plan ensures inclusive participation in decision-making processes and equitable access to resources

9.2. Way Forward

The sustainable management and conservation of biodiversity and ecosystems in Ghana require a robust, inclusive, and actionable approach. Climate change poses significant threats to these vital resources, and addressing these challenges demands strategic interventions. The following measures outline a comprehensive way forward to enhance the resilience of Ghana's biodiversity and ecosystems while fostering sustainable development.

1. Strengthening Institutional Capacity and Coordination

Effective implementation of adaptation strategies hinges on clear and well-defined institutional roles. Key institutions, including the Ministry of Environment, Science, Technology, and Innovation (MESTI), the Environmental Protection Agency (EPA), and local government authorities, must enhance inter-agency collaboration to streamline efforts and prevent overlaps. Regular inter-ministerial meetings, joint task forces, and shared implementation frameworks will ensure synergy, improve accountability, and optimize resource utilization. Strengthened institutional frameworks will also enable better alignment with national development goals and international obligations.

2. Enhancing Financial Mechanisms

Securing sustainable and sufficient funding is essential to the success of adaptation initiatives. Ministries and sectoral agencies must embed climate adaptation measures into their annual budgets, ensuring consistent financial allocation. Innovative financial mechanisms such as green bonds, ecosystem service payments, and public-private



partnerships (PPPs) should be explored to diversify funding sources. Additionally, partnerships with international donors and development partners, including the Green Climate Fund, can provide the necessary financial boost for large-scale conservation and adaptation projects.

3. Promoting Community-Based Conservation

Local communities are indispensable partners in biodiversity conservation and climate adaptation. Engaging community members in initiatives such as wetland restoration, mangrove replanting, and sustainable forest management fosters ownership and long-term commitment to these projects. Empowering communities through training, capacity building, and access to resources will enhance their ability to implement adaptive practices effectively. Success stories like the community-led restoration efforts in the Keta Lagoon Complex demonstrate the potential of grassroots involvement in achieving conservation goals.

4. Mainstreaming Gender in Biodiversity Management

Gender-responsive strategies are critical to ensuring equitable and effective adaptation

outcomes. Integrating gender considerations into all phases of biodiversity management, from planning to implementation, can address the specific vulnerabilities of women and marginalized groups. Collecting and utilizing sex-disaggregated data will provide insights into the unique needs of different demographic groups. Policies should also aim to promote equal access to resources, land ownership, and decision-making platforms, enhancing women's contributions to ecosystem conservation and resilience.

5. Leveraging Technology and Innovation

Modern technologies hold great potential for improving biodiversity monitoring and management. Geographic Information Systems (GIS), remote sensing, and early warning systems can provide real-time data for informed decision-making. These tools can enhance the detection of ecosystem changes, facilitate the tracking of species distributions, and support disaster preparedness efforts. Integrating such technologies into national conservation frameworks can significantly enhance the effectiveness and efficiency of adaptation measures.

6. Monitoring, Evaluation, and Learning (MEL)

A robust Monitoring, Evaluation, and Learning (MEL) framework is vital for tracking the progress of adaptation initiatives. Regular assessments of project outcomes, coupled with stakeholder feedback, can ensure transparency and accountability. MEL systems should be designed to identify areas of improvement, facilitate adaptive management, and document best practices for scaling successful interventions. These efforts will build institutional knowledge and foster a culture of continuous learning.

7. Strengthening Policy Integration

Ghana has a solid policy foundation, including the National Climate Change Policy (NCCP) and the Forestry Development Master Plan, which address climate resilience. However, greater policy coherence across sectors is necessary to maximize their impact. For instance, integrating biodiversity considerations into urban development plans can help mitigate habitat loss and promote green infrastructure. Policymakers must align sectoral strategies to ensure a unified approach to biodiversity conservation and sustainable development.



8. Addressing Implementation Challenges

Challenges such as inadequate funding, limited technical expertise, and weak institutional coordination hinder the effective implementation of adaptation strategies. These obstacles can be addressed through targeted capacity-building programs, sustainable financing strategies, and multi-stakeholder partnerships. Collaborations with academic institutions, international agencies, and private sector actors can provide the technical and financial support needed to bridge these gaps. Establishing knowledge-sharing platforms can further enhance capacities and foster innovation.



REFERENCES

1. Adzawla, W., Azumah, S. B., Anani, P. Y., & Donkoh, S. A. (2019). Gender perspectives of climate change adaptation in two selected districts of Ghana. *Heliyon*, 5(11).
2. Antwi-Agyei, P., Fraser, E. D., Dougill, A. J., Stringer, L. C., & Simelton, E. (2012). Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. *Applied Geography*, 32(2), 324-334.
3. Asante, F. A., & Amuakwa-Mensah, F. (2014). Climate change and variability in Ghana: Stocktaking. *Climate*, 3(1), 78-101.
4. Assan, J. K., Caminade, C., & Obeng, F. (2018). Gendered impacts of climate change on livelihoods: Insights from rural Ghana. *Environmental Development*, 25, 47-56. <https://doi.org/10.1016/j.envdev.2018.01.005>
5. Dixit, A., & McGray, H. (2013). Analyzing climate change adaptation options using Multi-Criteria Analysis. *World Resources Institute (WRI)*.
6. EPA. (2020). Integrating Gender Considerations Into Ghana's National Adaptation Plan Process: A Strategy for the Green Climate Fund Adaptation Planning Readiness Project. napgn-en-2020-integrating-gender-considerations-into-ghanas-nap-process.pdf (napglobalnetwork.org) (Accessed on 31/03/2024).
7. Environmental Protection Agency (EPA). (2021). Ghana Wetland Conservation Report. Accra: EPA Ghana.
8. Environmental Protection Agency (EPA). (2021). *National environmental report: Wetlands and water resources*. Accra, Ghana: EPA.
9. Fisheries Commission. (2022). State of Fisheries in Ghana. Accra: Ministry of Fisheries and Aquaculture Development.
10. Ghana Ministry of Environment, Science, Technology, and Innovation (MESTI). (2013).
11. *National Climate Change Policy (NCCP)*. Accra, Ghana: MESTI.
12. Ghana Ministry of Environment, Science, Technology, and Innovation (MESTI). (2022).
13. *Densu Delta Conservation Report*. Accra, Ghana: MESTI.
14. Ghana Ministry of Finance (MoF). (2015). *Nationally Determined Contributions (NDCs) Report*. Accra, Ghana: MoF.
15. Ministry of Food and Agriculture (MoFA). (2018). *Ghana Agricultural Sector Investment Plan: Investing for Food and Jobs*. Accra, Ghana: MoFA.
16. National Development Planning Commission (NDPC). (2018). *Ghana National Adaptation Plan Framework*. Accra, Ghana: NDPC.



17. Ghana Statistical Service (GSS). (2024): "Population and Housing Census." <https://www.statsghana.gov.gh> (Accessed on 21 December 2024).
18. IPBES (2016). The assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production. S.G. Potts, V. L. Imperatriz-Fonseca, and H. T. Ngo, (eds). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 552 pages.
19. IPCC, 2023: *Climate Change 2023: Synthesis Report*. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115, doi: 10.59327/IPCC/AR6-9789291691647.
20. Kokou, K., Syampungani, S., Chirwa, P. W., & Makhubele, L. (2024). Socio-ecological Management of Multifunctional Landscapes. In *Trees in a Sub-Saharan Multi-functional Landscape: Research, Management, and Policy* (pp. 267-304). Cham: Springer Nature Switzerland.
21. Lawson, E. T., Gordon, C., & Dzodzomenyo, M. (2020). Enhancing gender responsiveness in climate change adaptation policies: Lessons from Ghana. *Climate Policy*, 20(5), 599-613. <https://doi.org/10.1080/14693062.2020.1749185>
22. Malhi, Y., Franklin, J., Seddon, N., Solan, M., Turner, M. G., Field, C. B., & Knowlton, N. (2020). Climate change and ecosystems: threats, opportunities and solutions. *Philosophical Transactions of the Royal Society B*, 375(1794), 20190104.
23. Mensah, E., Asare, R., & Fiador, V. (2022). Women's empowerment in agriculture: Pathways to food security and resilience in Ghana. *Journal of Development Studies*, 58(3), 1-17. <https://doi.org/10.1080/00220388.2022.2038364>
24. Ministry of Environment, Science, Technology, and Innovation (MESTI). (2022). *Climate Action Report: Ghana*. Accra: MESTI.
25. Narh, J. (2024). Progress, challenges and prospects of the modified Taungya system in Ghana. *Agroforestry Systems*, 98(3), 767-782.
26. Nyarko, I., Nwaogu, C., & Miroslav, H. (2023). Forest Bioeconomy in Ghana: Understanding the Potential Indicators for Its Sustainable Development. *Forests*, 14(4), 804. <https://doi.org/10.3390/f14040804>
27. Ramsar Convention Secretariat. (2020). *Status of wetlands in Ghana: Challenges and opportunities*. Ramsar, Switzerland: Ramsar Convention Bureau.
28. World Bank. (2024.). Ghana - Climate data historical. Climate Knowledge Portal. Retrieved from <https://climateknowledgeportal.worldbank.org/country/ghana/climate-data-historical>
29. UNEP (United Nations Environment Programme). (2022). *Invasive species management in African wetlands*. Nairobi, Kenya: UNEP.
30. United Nations Environment Programme (UNEP). (2022). *Freshwater Biodiversity in West Africa*. Nairobi: UNEP.



31. United Nations Environment Programme (UNEP). (2022). Marine Pollution in West Africa. Nairobi: UNEP.
32. United Nations Environment Programme (UNEP). (2022). State of Coastal Wetlands in West Africa. Nairobi: UNEP.
33. United Nations Framework Convention on Climate Change (UNFCCC). (2020). Hydrological Impacts of Climate Change in Ghana. Bonn: UNFCCC Secretariat. United Nations Framework Convention on Climate Change (UNFCCC). (2020). Climate adaptation initiatives in coastal zones. Bonn, Germany: UNFCCC Secretariat.
34. Wrigley-Asante, C., & Dake, F. A. A. (2019). Gendered experiences of climate change in Ghana: The case of women farmers. *GeoJournal*, 84(3), 585-600. <https://doi.org/10.1007/s10708-019-09885-1>

