

Protected Areas for Climate Resilience in the Congo Basin

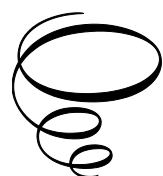
Protected Areas for Climate Resilience in the Congo Basin:

Governance and Policy Ramifications

By

Nyong Princely Awazi

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ACRONYMS

A

- **ABS** – Access and Benefit Sharing
- **AFSACA** – African Food Security and Climate Army
- **AI** – Artificial Intelligence
- **AIST** – African Institute of Science and Technology
- **AM** – Adaptive Management
- **APAN** – Asia Pacific Adaptation Network
- **AWF** – African Wildlife Foundation

B

- **BES** – British Ecological Society
- **BLF** – Biodiversity and Livelihoods Fund
- **BMZ** – German Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung)
- **BNFR** – Bafut-Ngemba Forest Reserve
- **BTU** – British Thermal Unit

C

- **CA** – Conservation Agriculture
- **CAFI** – Central African Forest Initiative
- **CAR** – Central African Republic
- **CARPE** – Central African Regional Program for the Environment
- **CAYS** – Cameroon Academy of Young Scientists
- **CBD** – Convention on Biological Diversity
- **CBFM** – Community-Based Forest Management
- **CBFP** – Congo Basin Forest Partnership
- **CBNRM** – Community-Based Natural Resource Management
- **CED** – Centre for Environment and Development (Cameroon)
- **CHM** – Clearing House Mechanism
- **CIFOR** – Center for International Forestry Research
- **CIG** – Common Initiative Group
- **CITES** – Convention on International Trade in Endangered Species of Wild Fauna and Flora
- **CLM** – Climate Law and Management
- **CM** – Cameroon
- **COLTECH** – College of Technology, University of Bamenda
- **COMIFAC** – Central African Forests Commission
- **COP** – Conference of the Parties
- **CORDEX** – Coordinated Regional Climate Downscaling Experiment
- **CPA** – Collaborative Protected Areas

D

- **DFR** – Department of Forestry and Resources
- **DNA** – Deoxyribonucleic Acid
- **DOI** – Digital Object Identifier
- **DRC** – Democratic Republic of Congo

- **DRR** – Disaster Risk Reduction
- **DSAA** – Dja Sustainable Agroforestry Association

E

- **ECCAS** – Economic Community of Central African States
- **EbA** – Ecosystem-based Adaptation
- **EbM** – Ecosystem-based Mitigation
- **eDNA** – Environmental DNA
- **EU** – European Union

F

- **FAO** – Food and Agriculture Organization of the United Nations
- **FTNS** – Fondation pour le Tri-National de la Sangha (Sangha Trinational Foundation)

G

- **GDP** – Gross Domestic Product
- **GHG** – Greenhouse Gas
- **GIS** – Geographic Information Systems
- **GIZ** – German International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit)
- **GPS** – Global Positioning System

I

- **IPCC** – Intergovernmental Panel on Climate Change
- **IUCN** – International Union for Conservation of Nature
- **IUAF** – International Union of Agroforestry
- **IUFRO** – International Union of Forest Research Organizations

M

- **MDPI** – Multidisciplinary Digital Publishing Institute
- **MtC** – Million tonnes of Carbon
- **MtCO_{2e}** – Million tonnes of Carbon Dioxide Equivalent
- **MAB** – Man and the Biosphere Programme (UNESCO)

N

- **NAP** – National Adaptation Plan
- **NBSAP** – National Biodiversity Strategy and Action Plan
- **NDCs** – Nationally Determined Contributions
- **NGO** – Non-Governmental Organization
- **NP** – National Park
- **NTFPs** – Non-Timber Forest Products

P

- **PA** – Protected Area
- **PAs** – Protected Areas
- **PES** – Payment for Ecosystem Services

R

- **REDD+** – Reducing Emissions from Deforestation and Forest Degradation (plus sustainable forest management, conservation and carbon stock enhancement)
- **RCP** – Representative Concentration Pathway

S

- **SDGs** – Sustainable Development Goals
- **SMART** – Spatial Monitoring and Reporting Tool
- **SYRFM** – Scholars Academic and Scientific Society Young Research Fellow Member

T

- **TC4BE** – Transformative Change for Biodiversity and Equity
- **TEK** – Traditional Ecological Knowledge
- **TNS** – Tri-national Sangha

U

- **UNESCO** – United Nations Educational, Scientific and Cultural Organization
- **UNFCCC** – United Nations Framework Convention on Climate Change

W

- **WCMC** – World Conservation Monitoring Centre
- **WRI** – World Resources Institute

Y

- **YALI** – Young African Leaders Initiative

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CHAPTER 1

INTRODUCTION TO PROTECTED AREAS FOR A CLIMATE-RESILIENT FUTURE IN THE CONGO BASIN

Abstract

Chapter 1 establishes the ecological, socio-economic, and policy foundations for understanding how protected areas (PAs) can serve as vital instruments for climate resilience in one of the planet's most important ecosystems. It begins with an overview of the Congo Basin's global significance, emphasising its unparalleled biodiversity, role as a major carbon sink, and provision of essential ecosystem services. The chapter situates these ecological assets within the socio-economic realities of local and indigenous communities, for whom forests provide food, medicine, cultural identity, and livelihoods. The section on climate change presents observed trends and projections, including temperature increases, altered rainfall patterns, and more frequent extreme events, which threaten both ecosystems and human well-being. It highlights the interdependence between climate stability and PA effectiveness, framing PAs as critical for both mitigation (through carbon storage and emissions reduction), and adaptation, by buffering communities from climate shocks and safeguarding ecosystem services. The historical and policy context traces the evolution of PAs from colonial-era game reserves to contemporary, climate-integrated management systems, influenced by global agreements such as the Convention on Biological Diversity, the Paris Agreement, and regional initiatives like COMIFAC's Convergence Plan. Despite progress, the chapter details persistent challenges, including deforestation, mining, infrastructure expansion, governance gaps, funding shortfalls, and social conflicts. Opportunities for advancing climate-resilient PA management include integrating PAs into national adaptation and mitigation plans, tapping into carbon markets and conservation trust funds, applying remote sensing and SMART patrol technologies, and strengthening community co-management. The rationale for the book is rooted in bridging gaps between science, policy, and practice, adopting integrated landscape approaches, and aligning conservation with sustainable development. The chapter concludes with the structure of the book, outlining how subsequent chapters move from context-setting and problem analysis to solutions, financing, and real-world case studies, culminating in a synthesised call to action in the final chapter.

Key words: Congo Basin; Protected areas; Climate resilience; Biodiversity conservation; Carbon storage; Ecosystem-based adaptation; Governance frameworks; Sustainable development

1.1 Background: Overview of the Congo Basin's Ecological Significance

The Congo Basin, covering approximately 3.7 million km² across six Central African countries (Cameroon, the Central African Republic, the Democratic Republic of Congo (DRC), the Republic of Congo, Equatorial Guinea, and Gabon), constitutes the second-largest tropical rainforest on Earth after the Amazon (Jiang et al., 2023; Wang et al., 2025). This vast biome contains an estimated 240 million hectares of forest, representing about 18% of the world's remaining tropical forests (Shapiro et al., 2021; Atyi, 2022). The ecological significance of the Congo Basin extends far beyond its size; it is home to extraordinary biological diversity, complex ecological processes, and globally important ecosystem services. The basin harbours more than 10,000 species of tropical plants, with roughly 30% being endemic (Sinkgraven, 2024). Faunal diversity is equally remarkable, including over 1,000 species of birds, 400 species of mammals, and some of the world's most iconic megafauna such as the forest elephant (*Loxodonta cyclotis*), western lowland gorilla (*Gorilla gorilla gorilla*), okapi (*Okapia johnstoni*), and bongo antelope (*Tragelaphus eurycerus*) (Fonteyn, 2022).

This high degree of endemism and species richness underscores the basin's role as a global biodiversity hotspot and a priority area for conservation (Katemo Manda et al., 2023; Nneji et al., 2023). Ecologically, the Congo Basin serves as the hydrological heart of Central Africa. Its extensive river systems (including the Congo River, the second-largest river in the world by discharge), support freshwater ecosystems of exceptional productivity (Datok, 2021; Tshimanga et al., 2021; Kitambo, 2023). These systems regulate regional water cycles, influence rainfall patterns across Africa, and sustain both terrestrial and aquatic biodiversity. The dense canopy cover plays a critical role in local and regional climate moderation, influencing evapotranspiration and cloud formation (Alber et al., 2021; Milena, 2025).

From a global perspective, the Congo Basin's forests are indispensable to both biodiversity conservation and climate regulation. The forests store an estimated 30-38 billion metric tonnes of carbon in above- and below-ground biomass, making the region one of the largest terrestrial carbon reservoirs in the world (Crezee et al., 2022; Garcin et al., 2022). The peatlands of the central basin, discovered in recent years, alone hold around 30 billion tonnes of carbon, equivalent to three years of global fossil fuel emissions (Crezee, 2022). The Congo Basin acts as a significant carbon sink, sequestering approximately 0.61–0.63 gigatonnes of CO₂ annually (Jiang et al., 2023). However, this capacity is increasingly threatened by deforestation, forest degradation, and climate change-induced disturbances. Unlike many other tropical forests, large tracts of the Congo Basin remain relatively intact, but pressures are escalating due to industrial logging, agriculture, mining, and infrastructure development (Atyi, 2022). The basin's intact ecosystems also contribute to climate regulation beyond carbon storage. They influence atmospheric circulation patterns, contributing to rainfall stability across the Sahel and even impacting weather systems in the North Atlantic (Burgin et al., 2025; Adhikari et al., 2025). Maintaining the integrity of these forests is therefore critical not only for regional climatic stability but also for global climate systems. The Congo Basin is a cornerstone for achieving multiple global environmental commitments, including the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), and the Sustainable Development Goals (SDGs), particularly SDG 13 (Climate Action), SDG 15 (Life on Land), and SDG 6 (Clean Water and Sanitation).

Beyond its ecological and climatic importance, the Congo Basin sustains over 80 million people, including approximately 150 distinct ethnic groups, many of whom are indigenous peoples such as the Baka, Bagyeli, Bakoko, BaAka, and Twa (Tongele, 2021; Nsah, 2023). The forests provide food, medicine, fuelwood, building materials, and cultural resources essential to local livelihoods (Nghonda et al., 2023; Opelele Omeno et al., 2024; Nteranya, 2024; Awazi, 2025). The majority of rural communities in the Congo Basin practice small-scale agriculture, fishing, and hunting. Non-timber forest products (NTFPs), including bush mango (*Irvingia gabonensis*), kola nuts, honey, rattan, and medicinal plants, are crucial sources of income and nutrition (Mendako et al., 2022; Ndumbe et al., 2022). Bushmeat remains a significant protein source for many communities, though overexploitation has raised sustainability concerns (Batumike et al., 2021; Kazadi et al., 2025). For indigenous peoples, the forest is more than a resource base, it is integral to their cultural identity, spirituality, and cosmology. Sacred groves, spiritual sites, and traditional ecological knowledge (TEK) systems embedded within these landscapes represent millennia of sustainable resource management practices (Trefon, 2023). The Congo Basin also contributes substantially to national and regional economies. Timber exports, mining revenues, and agricultural commodities such as cocoa, coffee, and palm oil are key economic drivers (Ngouhouo-Poufoun et al., 2024). However, these activities often lead to trade-offs between short-term economic gains and long-term ecological integrity. Ecotourism, though still underdeveloped compared to other regions, offers potential for sustainable economic diversification, particularly in areas like Dzanga-Sangha in the Central African Republic and Odzala-Kokoua in the Republic of Congo. In addition to direct livelihood benefits, the basin's ecosystems provide regulating services such as water purification, flood control, and soil fertility maintenance, all of which underpin agricultural productivity and food security (Nkoulou et al., 2021; Cédric et al., 2023). Disruption of these services due to deforestation or

climate change disproportionately affects the poorest communities, exacerbating vulnerability and undermining resilience.

The Congo Basin's ecological, climatic, and socio-economic roles position it as a critical region for global sustainability. It is a biodiversity reservoir, a climate regulator, and a livelihood lifeline for millions. Yet, these functions are intricately interconnected, degradation of forest ecosystems compromises both climate regulation and human well-being, while socio-economic pressures can erode conservation gains. Understanding and protecting the Congo Basin is therefore not only a regional priority but a global imperative. As subsequent sections of this chapter will show, climate change presents both a threat and an opportunity for redefining protected areas as central tools for safeguarding this globally significant landscape.

1.2 Climate Change and the Congo Basin

1.2.1 Trends and Projections of Climate Change Impacts in the Region

The Congo Basin is experiencing increasingly evident climate change impacts, with significant consequences for ecosystems, biodiversity, and human livelihoods. Climatic analyses over the past four decades reveal rising mean annual temperatures, increased variability in rainfall patterns, and a greater frequency of extreme events such as floods and droughts (Karam et al., 2022; Mabrouk et al., 2022). Between 1970 and 2020, average temperatures in Central Africa rose by approximately 0.6–1.0°C, with more pronounced warming trends during the dry season (Cook et al., 2025). Projections from multiple global climate models (GCMs) suggest that by 2050, mean temperatures in the Congo Basin could rise by 1.5–2.5°C under moderate emission scenarios (RCP4.5), and by up to 3–4°C under high emission scenarios (RCP8.5) (Trisos et al., 2022; Khomsi et al., 2023). Rainfall trends are more complex. Historical data show inter-annual variability without a uniform trend in total annual precipitation. However, climate projections indicate an increase in rainfall variability, with potential for more intense wet seasons in the north and prolonged dry spells in the south (Dosio et al., 2021; Ndehedehe and Agutu, 2022; Nicholson et al., 2022; Efon et al., 2023). These changes are likely to disrupt hydrological regimes, affect agricultural cycles, and exacerbate flood and drought risks. Table 1.1 presents observed and projected climate changes in the Congo Basin.

Table 1.1: Observed and Projected Climate Changes in the Congo Basin

Climate Variable	Observed Changes (1970–2020)	Projected Changes 2050 (RCP4.5)	Projected Changes 2100 (RCP8.5)	Key Implications
Mean temperature	+0.6–1.0°C increase	+1.5–2.5°C	+3.0–4.0°C	Increased heat stress on crops, wildlife, and humans
Rainfall totals	High inter-annual variability	+5–10% in northern basin	+10–15% (intensified wet seasons)	Flooding risk in northern regions
Rainfall patterns	Shift in onset/cessation	Shorter wet seasons in south	More erratic distribution	Reduced predictability for agriculture
Extreme events	More frequent floods/droughts	Further increases expected	Severe flood/drought cycles	Infrastructure damage, displacement

Table 1.1 presents observed and projected climate changes in the Congo Basin, highlighting significant environmental shifts with serious implications. Between 1970 and 2020, the region experienced a mean temperature increase of 0.6–1.0°C. Projections suggest further warming, with

temperatures rising by 1.5–2.5°C by 2050 under RCP4.5, and reaching 3.0–4.0°C by 2100 under RCP8.5. This warming is expected to increase heat stress on crops, wildlife, and human health. Rainfall totals have shown high inter-annual variability, but are projected to rise by 5–10% in the northern basin by 2050, and by 10–15% by 2100, potentially intensifying wet seasons and raising flood risks. Rainfall patterns are also shifting, with changes in the onset and cessation of rains already observed. By 2050, the southern basin may experience shorter wet seasons, and by 2100, rainfall distribution is expected to become more erratic, reducing agricultural predictability. Extreme weather events, such as floods and droughts, have become more frequent and are projected to intensify, leading to severe flood/drought cycles by the end of the century. These trends, as summarized in Table 1.1, indicate growing threats to infrastructure, food security, and human settlements, emphasizing the urgent need for adaptive measures across the Congo Basin.

1.2.2 Vulnerability of Ecosystems and Species

The Congo Basin’s ecosystems are diverse, ranging from dense evergreen forests to swamp forests, savannas, and wetlands. Climate change interacts with other anthropogenic pressures (such as deforestation, mining, and agricultural expansion), to heighten ecosystem vulnerability (Yuh et al., 2024). Rising temperatures and shifting rainfall patterns are expected to alter forest composition and structure. Species adapted to cooler or wetter microclimates may face range contractions, while more drought-tolerant species could expand (Réjou-Méchain et al., 2021; Sun et al., 2022; Kasongo Yakusu et al., 2023; Kearsley et al., 2024). This shift has implications for biodiversity as well as carbon storage, as certain high-biomass tree species may decline. Central Congo Basin peatlands, which store about 30 billion tonnes of carbon, are particularly sensitive to hydrological changes. Prolonged droughts or drainage for agriculture can trigger large-scale carbon emissions, reversing their role as carbon sinks. The forest elephant (*Loxodonta cyclotis*), western lowland gorilla (*Gorilla gorilla gorilla*), and okapi (*Okapia johnstoni*) are all vulnerable to climate-induced habitat fragmentation. Changes in fruiting patterns of key tree species may reduce food availability, exacerbating population declines already driven by poaching (Chapman et al., 2021). Table 1.2 shows some selected species vulnerable to climate change in the Congo Basin.

Table 1.2: Selected Species Vulnerable to Climate Change in the Congo Basin

Species	Primary Habitat	Climate Sensitivity	Main Threats
Forest elephant (<i>Loxodonta cyclotis</i>)	Lowland tropical forest	Sensitive to water scarcity & vegetation change	Poaching, habitat loss
Western lowland gorilla (<i>Gorilla gorilla gorilla</i>)	Swamp & lowland forests	Sensitive to food resource shifts	Hunting, disease
Okapi (<i>Okapia johnstoni</i>)	Dense rainforest	Narrow range tolerance	Habitat loss, mining
African grey parrot (<i>Psittacus erithacus</i>)	Forest edges	Nesting tree loss from storms	Illegal trade

Table 1.2 outlines several species in the Congo Basin that are particularly vulnerable to climate change due to their habitat needs and ecological sensitivities. The forest elephant (*Loxodonta cyclotis*), which inhabits lowland tropical forests, is highly sensitive to water scarcity and vegetation changes. While climate impacts pose a serious risk, poaching and habitat loss remain its primary threats. The western lowland gorilla (*Gorilla gorilla gorilla*), found in swamp and lowland forests, is vulnerable to shifts in food availability caused by changing rainfall and temperature patterns. Hunting and disease further exacerbate its decline. The okapi (*Okapia johnstoni*), which lives in dense rainforest, has a narrow tolerance for environmental change, making it particularly sensitive to even small climate shifts. It is mainly threatened by habitat destruction and mining activities. Lastly, the African grey parrot (*Psittacus erithacus*), common around forest edges, suffers from the

loss of nesting trees, especially due to increased storm activity linked to climate change. Illegal trade is also a major threat to its population. Table 1.2 highlights how climate change, in combination with human pressures, is accelerating the vulnerability of key species in the Congo Basin, emphasizing the need for integrated conservation and climate adaptation strategies.

1.2.3 Interconnectedness Between Climate Stability and Protected Area Management

Protected areas in the Congo Basin (including national parks, reserves, and community-managed forests), are critical nodes in maintaining climate stability. Healthy forests regulate local and regional climates through evapotranspiration, cloud formation, and rainfall recycling (Worden et al., 2021). Conversely, climate stability is vital for maintaining the ecological integrity of these areas. When protected areas are effectively managed, they sustain carbon stocks, regulate water cycles, and maintain habitats, which in turn enhance climate resilience for surrounding landscapes and human populations (Mukaku Kazadi et al., 2024; Nampindo and Randhir, 2024). However, climate change can undermine protected area effectiveness by shifting species ranges outside designated boundaries, altering fire regimes, and increasing susceptibility to invasive species (Doumenge et al., 2021; Burgin et al., 2025). Without adaptive management, these changes may erode both biodiversity and the ecosystem services that protected areas are meant to safeguard. Figure 1.1 shows the climate-protected area feedback mechanism.

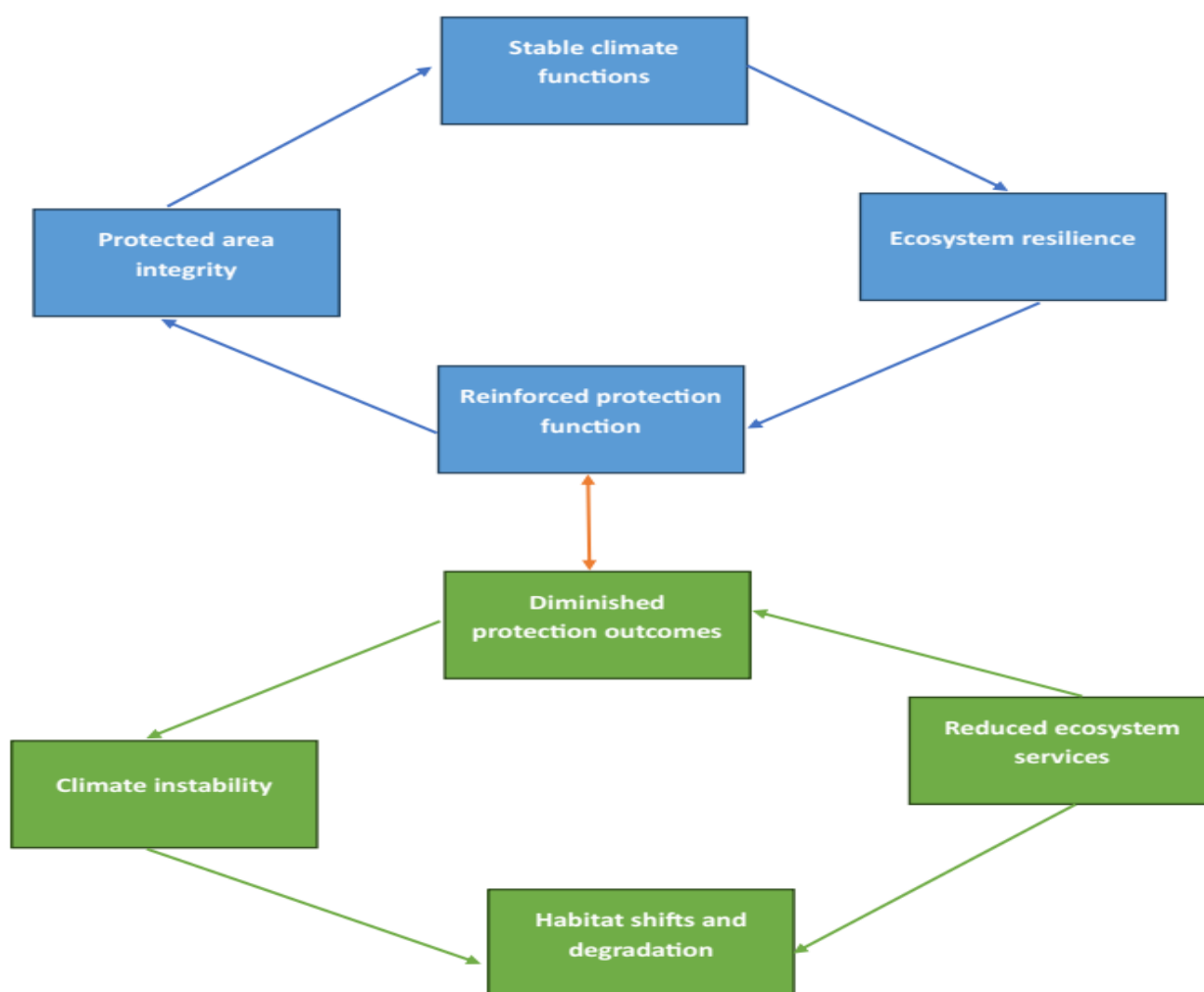


Figure 1.1: Climate–Protected Area Feedback Mechanisms

Figure 1.1 presents a conceptual diagram illustrating the dynamic feedback mechanisms between climate and protected areas. It highlights two interconnected cycles: a positive feedback loop that

reinforces conservation success and a negative feedback loop that undermines it. The positive loop, shown in blue, begins with *protected area integrity*. Well-managed and intact protected areas sustain *stable climate functions*, such as carbon sequestration, regulation of water cycles, and microclimate stability. These functions enhance *ecosystem resilience*, enabling biodiversity and ecological systems to withstand disturbances such as droughts, floods, or disease outbreaks. This resilience feeds into *reinforced protection success*, as resilient ecosystems are easier to conserve and manage effectively. The cycle then loops back to strengthen *protected area integrity*, creating a virtuous circle where conservation outcomes and climate stability mutually reinforce one another. In contrast, the negative loop, shown in green demonstrates how climate change can destabilize protected area outcomes. The cycle starts with *climate instability*, including rising temperatures, erratic rainfall, and extreme events. These pressures trigger *habitat shifts and degradation*, disrupting species distributions, fragmenting habitats, and eroding ecological functions. This leads to *reduced ecosystem services*, such as declines in pollination, water purification, and carbon storage. As these services diminish, the result is *diminished protection outcomes*, whereby the effectiveness of protected areas in conserving biodiversity and supporting human well-being is compromised. This, in turn, exacerbates *climate instability*, fueling a vicious cycle of degradation and reduced resilience. Thus, the figure captures the dual potential pathways in the relationship between climate and protected areas. If integrity is maintained and resilience is nurtured, protected areas can act as stabilizing forces that bolster climate adaptation and mitigation. Conversely, unchecked climate impacts can erode conservation effectiveness, pushing protected areas into a downward spiral. This duality underscores the urgent need for integrated climate and conservation strategies.

Climate change in the Congo Basin is not an abstract future threat, it is a present reality. Rising temperatures, shifting rainfall patterns, and more frequent extremes are already reshaping ecosystems, threatening species, and undermining livelihoods. The vulnerability of the region is compounded by socio-economic challenges, making the role of well-managed protected areas even more critical. As subsequent sections will demonstrate, the interplay between climate stability and conservation is a two-way street: effective protected area management can bolster climate resilience, while unchecked climate change can erode conservation gains.

1.3 Protected Areas as a Climate-Resilience Strategy

Protected areas (PAs) in the Congo Basin are not only biodiversity strongholds but also foundational tools for climate change mitigation and adaptation. By safeguarding intact ecosystems, these areas protect carbon stocks, regulate hydrological systems, and buffer human and ecological communities from the adverse effects of climate change. This section explores the definition and typology of PAs in the region, their role in mitigation through carbon storage and emission reductions, and their role in adaptation through the provision of ecosystem services and protection from extreme events.

1.3.1 Definition and Types of Protected Areas in the Congo Basin

The International Union for Conservation of Nature (IUCN) defines a protected area as “a clearly defined geographical space, recognised, dedicated and managed... to achieve the long-term conservation of nature with associated ecosystem services and cultural values” (Dudley, 2008). In the Congo Basin, PAs are established under national legislation but also recognised within international frameworks such as UNESCO World Heritage Sites, Ramsar Wetlands of International Importance, and transboundary conservation agreements. The typology of protected areas in the Congo Basin is presented in **Table 1.3**.

Table 1.3: Major Categories of Protected Areas in the Congo Basin

Category	Description	Examples	Surface Area (approx.)	Key Functions
National Parks	Large natural areas set aside to protect ecological integrity	Salonga NP (DRC), Lobéké NP (Cameroon)	1,000–36,000 km ²	Biodiversity conservation, tourism, research
Wildlife Reserves and Sanctuaries	Areas focusing on specific species or habitats	Dja Faunal Reserve (Cameroon), Banyang-Mbo Sanctuary (Cameroon)	500–5,000 km ²	Species protection, research
Community Conserved Areas	Areas managed by local communities for conservation & sustainable use	Community Forests in Cameroon	5–100 km ²	Livelihoods, NTFP harvesting, cultural heritage
Transboundary Protected Areas	Ecosystems crossing political borders under joint management	Sangha Trinational (Cameroon, CAR, Congo)	~28,000 km ²	Regional cooperation, landscape connectivity
Ramsar Sites and Wetland Reserves	Wetlands of international importance under the Ramsar Convention	Waza Logone Floodplain (Cameroon)	Variable	Hydrological regulation, fisheries

The diversity of PA types in the Congo Basin reflects a range of management objectives (from strict biodiversity preservation to integrated resource use), and offers flexibility for aligning conservation with local development needs. Table 1.3 presents the major categories of protected areas in the Congo Basin, highlighting their purposes, scale, and contributions to conservation. National Parks are the largest protected areas, ranging from 1,000 to 36,000 km², established to preserve ecological integrity. Examples include Salonga National Park in the Democratic Republic of Congo (DRC) and Lobéké National Park in Cameroon, which support biodiversity conservation, tourism, and scientific research. Wildlife Reserves and Sanctuaries, such as the Dja Faunal Reserve and Banyang-Mbo Sanctuary in Cameroon, are smaller (500–5,000 km²) and focus on protecting specific species or habitats, also serving research purposes. Community Conserved Areas are locally managed zones, typically 5–100 km², like Community Forests in Cameroon. These areas emphasize sustainable use, non-timber forest product (NTFP) harvesting, and cultural preservation, supporting local livelihoods. Transboundary Protected Areas, such as the Sangha Trinational shared by Cameroon, the Central African Republic, and the Republic of Congo, cover around 28,000 km² and promote regional cooperation and landscape connectivity. Lastly, Ramsar Sites and Wetland Reserves, like the Waza Logone Floodplain, vary in size and are designated for their global importance in hydrological regulation and fisheries. Table 1.3 underscores the diversity and strategic value of protected areas in sustaining the Congo Basin’s ecological and human systems.

1.3.2 Role of Protected Areas in Climate Change Mitigation

Protected areas contribute to climate change mitigation primarily through carbon storage and avoided emissions. Forests in the Congo Basin contain massive carbon stocks in both above-ground biomass and soils, including peatlands (Sciumbata et al., 2023). Effective PA management prevents deforestation and degradation, maintaining these carbon reservoirs. For above-ground biomass, estimates place carbon density in intact forests at 150–250 tonnes C/ha (Migolet et al., 2022; Kossi

Ditsouga et al., 2024). Peatlands store ~30 billion tonnes of carbon, making them globally significant for climate regulation (Ribeiro et al., 2021; Strack et al., 2022). Mangroves and wetlands though smaller in area, store disproportionately high amounts of carbon per unit area (Awazi, 2025b). Deforestation releases stored carbon into the atmosphere. By reducing deforestation rates, PAs help avoid emissions. For example, REDD+ projects in and around PAs in the Republic of Congo and DRC have demonstrated that effective enforcement can reduce emissions by up to 60% in target zones (Kengoum et al., 2024). Table 1.4 presents the estimated carbon benefits of selected PAs in the Congo Basin.

Table 1.4: Estimated Carbon Benefits of Selected PAs in the Congo Basin

Protected Area	Country	Carbon Stock (MtC)	Annual Emissions Avoided (MtCO _{2e})
Salonga NP	DRC	2,900	12.4
Lobéké NP	Cameroon	350	1.8
Sangha Trinational	Cameroon, CAR, Congo	800	3.5
Dja Faunal Reserve	Cameroon	400	2.1

Table 1.4 highlights the estimated carbon benefits of selected protected areas (PAs) in the Congo Basin, emphasizing their critical role in climate change mitigation through carbon storage and emissions reduction. Salonga National Park in the Democratic Republic of Congo (DRC) stands out with the highest carbon stock, estimated at 2,900 million tonnes of carbon (MtC), and avoids approximately 12.4 million tonnes of CO₂-equivalent (MtCO_{2e}) emissions annually. Lobéké National Park in Cameroon holds around 350 MtC and prevents 1.8 MtCO_{2e} in emissions each year. The Sangha Trinational, a transboundary area spanning Cameroon, the Central African Republic (CAR), and the Republic of Congo, stores about 800 MtC and avoids 3.5 MtCO_{2e} annually. Meanwhile, the Dja Faunal Reserve in Cameroon contributes with 400 MtC in carbon stock and an estimated 2.1 MtCO_{2e} in avoided emissions per year. These figures, presented in Table 1.4, demonstrate that protected areas in the Congo Basin not only preserve biodiversity but also deliver substantial climate benefits. By safeguarding vast carbon-rich forests, these areas play a vital role in reducing greenhouse gas emissions, reinforcing the need for continued investment in conservation and sustainable management across the region.

1.3.3 Role of Protected Areas in Climate Change Adaptation

Mitigation alone is insufficient for building resilience in the Congo Basin; adaptation is equally vital. PAs support adaptation by maintaining ecosystem services, creating buffers against climate extremes, and preserving genetic diversity that supports ecological and agricultural resilience. Some ecosystem services provided by protected areas which aid in climate change adaptation include water regulation, soil protection, as well as pollination and pest control. Forested watersheds in PAs help stabilise stream flows, reducing both floods and droughts (Baumgartner et al., 2022; Awazi et al., 2025). Vegetation cover prevents erosion, preserving soil fertility essential for agriculture. Forest habitats sustain pollinators and natural predators that support crop production. Moreover, these protected areas also contribute to buffering against extreme events and fostering cultural and livelihood resilience. Wetlands and floodplain PAs absorb excess rainfall, reducing flood damage to downstream settlements. For example, the Waza Logone floodplain in Cameroon has reduced downstream flood impacts during high rainfall years (Moritz et al., 2024; Mahamat et al., 2025). Community-based PAs integrate traditional ecological knowledge into management, which strengthens culturally relevant adaptation strategies (van Der Hoek et al., 2024; Nghonda et al., 2025). Sustainable harvesting of NTFPs during climate shocks provides safety nets for households.

1.3.4 Synergies Between Mitigation and Adaptation in Protected Area Management

Protected areas that are well-designed and managed can deliver co-benefits for both mitigation and adaptation (Cannizzo et al., 2024). For example, a mangrove reserve stores carbon in biomass (mitigation) and shields coastal communities from storm surges (adaptation); and forest corridors in transboundary landscapes enable species migration in response to climate change, while also preserving carbon stocks. Figure 1.2 presents the mitigation-adaptation synergy pathways in protected areas in the Congo Basin.

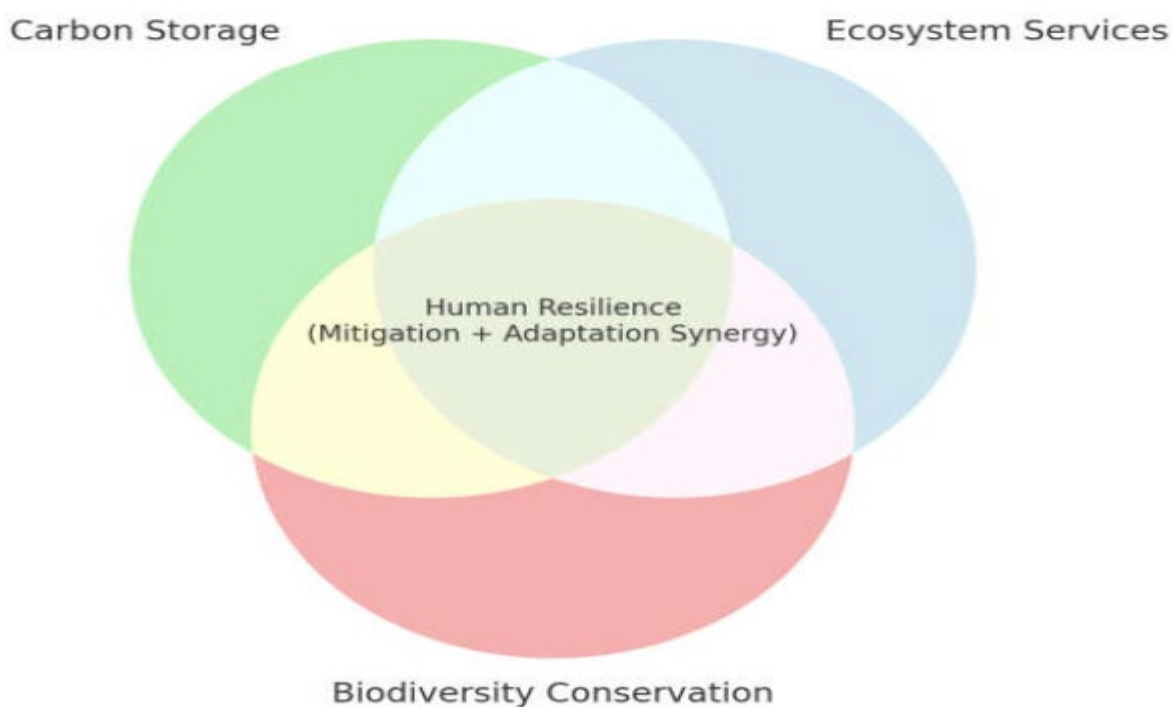


Figure 1.2: Mitigation–Adaptation Synergy Pathways in PAs

Figure 1.2 illustrates the interlinked pathways through which protected areas in the Congo Basin generate synergies between climate change mitigation and adaptation. The diagram uses three overlapping circles (representing carbon storage, ecosystem services, and biodiversity conservation), to demonstrate how these domains converge to enhance human resilience at their intersection. The first circle, *carbon storage*, highlights the mitigation role of protected areas. The vast forests of the Congo Basin act as carbon sinks, absorbing atmospheric carbon dioxide and reducing greenhouse gas concentrations. This mitigates global climate change while maintaining ecological stability. The second circle, *ecosystem services*, emphasizes the adaptation benefits derived from protected areas. These services include water regulation, soil fertility maintenance, pollination, and climate regulation at local and regional scales. By supporting livelihoods and buffering communities against climate extremes such as droughts and floods, ecosystem services strengthen adaptive capacity. The third circle, *biodiversity conservation*, underscores the role of protected areas in maintaining species richness and ecological integrity. High biodiversity enhances ecosystem resilience, allowing natural systems to recover from disturbances and continue delivering essential services. Moreover, conserving species ensures genetic diversity, which is crucial for long-term ecological adaptation under changing climatic conditions. At the center of the diagram, where all three circles overlap, lies human resilience which is the ultimate outcome of synergies between mitigation and adaptation. When carbon storage, ecosystem services, and biodiversity conservation are simultaneously prioritized, protected areas deliver multiple co-benefits that improve food security, health, water availability, and disaster preparedness for local communities. This integrated approach creates a reinforcing loop: strong ecosystems enhance human well-being, while resilient communities are better positioned to support conservation efforts. The figure therefore conveys that

the effectiveness of protected areas in the Congo Basin depends not on isolated functions, but on the convergence of ecological and social benefits. The synergy between mitigation and adaptation pathways offers a holistic strategy for addressing climate change while safeguarding biodiversity and human livelihoods.

1.3.5 Challenges and Enabling Conditions

While PAs offer clear benefits, realising their climate potential requires effective governance (inclusive decision-making, clear legal status); adequate financing (e.g., trust funds, carbon markets); monitoring capacity (use of remote sensing, community-based monitoring); and community engagement (benefit-sharing, livelihood integration) (Doumenge et al., 2021; Tchamba and Keutcheu (2022); Majambu et al., 2023; Awazi, 2025c).

Protected areas in the Congo Basin represent a natural climate solution with multiple dimensions: they store vast amounts of carbon, provide life-supporting ecosystem services, and buffer against climate hazards. Their role in both mitigation and adaptation is not hypothetical, it is measurable, significant, and globally relevant. However, unlocking their full potential requires robust governance, sustainable financing, and integration into broader climate and development strategies.

1.4 Historical and Policy Context

Protected area (PA) development in the Congo Basin has evolved through a complex interplay of colonial history, post-independence nation-building, international conservation movements, and emerging climate change imperatives. Understanding this historical trajectory and the associated policy frameworks is essential for appreciating how PAs can be leveraged for climate resilience today.

1.4.1 Evolution of Protected Areas in the Congo Basin

1.4.1.1 Colonial Period (Late 1800s–1960s)

The origins of PAs in the Congo Basin can be traced to colonial conservation policies aimed at preserving game for hunting elites and protecting commercially valuable timber species (Inogwabini, 2014; Walters and Wardell, 2023). Early PAs were established primarily for wildlife preservation without meaningful consultation with local communities, often resulting in the displacement of indigenous peoples (Pyhälä et al., 2016). For example, the Waza National Park (Cameroon), established in 1934 under French colonial rule primarily for game conservation (Tchamba, 1996; Kelly, 2013; Kelly, 2015); and the Garamba National Park (DRC) created in 1938, focused on iconic species such as elephants and giraffes (D’haen, 2017; Walters and Wardell, 2023).

1.4.1.2 Post-Independence Expansion (1960s–1980s)

Following independence, many states retained colonial PA structures but began integrating conservation into national development planning. The 1970s and 1980s saw the establishment of large forested PAs, often supported by international NGOs and UNESCO’s Man and the Biosphere Programme. Key drivers included biodiversity protection, tourism promotion, and maintaining access to global conservation funding. Salonga National Park (DRC), designated in 1970, became Africa’s largest tropical forest park (36,000 km²).

1.4.1.3 Integration with Sustainable Development (1990s–2000s)

The 1992 Rio Earth Summit catalysed the adoption of the Convention on Biological Diversity (CBD) and Agenda 21, which pushed for integrating conservation with sustainable development and local participation (Kreienkamp, 2022). Community forestry policies were introduced in Cameroon (1994 Forestry Law) and Gabon, giving local populations some rights over forest resources within

designated areas (Omam and Yasuoka, 2023). Transboundary conservation emerged, such as the Sangha Trinational (Cameroon, CAR, Congo), a UNESCO World Heritage Site established in 2000.

1.4.1.4 Climate-Integrated Conservation (2010s–Present)

In the past decade, climate change has become a central driver of PA policy. REDD+ initiatives, climate adaptation projects, and ecosystem-based adaptation frameworks have positioned PAs as nature-based solutions to climate change (Lipka et al., 2023; Awazi et al., 2024). Peatland mapping in the central basin (Sonwa et al., 2022; Dargie et al., 2025) elevated the global importance of Congo Basin PAs for carbon storage. Integration with national climate strategies, such as Cameroon’s updated NDCs in 2021, links PA expansion to climate mitigation targets.

1.4.2 International Agreements Influencing Policy

International environmental agreements have profoundly shaped the governance and strategic orientation of PAs in the Congo Basin (Table 1.5).

Table 1.5: Key International Agreements and Their Implications for Congo Basin PAs

Agreement	Year Ratified by Basin Countries	Key Provisions	Implications for PAs
Convention on Biological Diversity (CBD)	1994–1995	Establish PA networks, integrate conservation into national planning	Expanded PA systems, biodiversity action plans
Ramsar Convention	1980s–2000s	Conserve wetlands of international importance	Designation of Ramsar sites (e.g., Waza Logone Floodplain)
UNFCCC & Paris Agreement	1994; 2016	Mitigate GHG emissions, enhance adaptation	REDD+ integration, nature-based solutions in NDCs
World Heritage Convention	1970s–1980s	Protect cultural/natural heritage sites	Listing of parks such as Dja Faunal Reserve, Salonga National Park
CITES	1980s	Regulate trade in endangered species	Anti-poaching enforcement, trade bans on ivory and bushmeat species

These agreements not only set conservation targets but also unlock funding, technical support, and monitoring frameworks that bolster PA resilience. Table 1.5 outlines key international agreements ratified by Congo Basin countries and their implications for protected areas (PAs). The Convention on Biological Diversity (CBD), ratified between 1994 and 1995, has driven the expansion of PA networks and the integration of biodiversity into national development plans, leading to biodiversity action plans across the region. The Ramsar Convention, adopted from the 1980s to 2000s, promotes the conservation of wetlands, resulting in the designation of important sites like the Waza Logone Floodplain. The United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement (ratified in 1994 and 2016, respectively) focus on reducing greenhouse gas emissions and adapting to climate change. These agreements have encouraged the integration of REDD+ initiatives and nature-based solutions into Nationally Determined Contributions (NDCs). The World Heritage Convention, ratified in the 1970s–1980s, ensures protection for globally significant natural and cultural sites, such as Dja Faunal Reserve and Salonga National Park. Lastly, CITES, adopted in the 1980s, regulates international trade in endangered species, supporting anti-poaching efforts and trade restrictions on ivory and bushmeat. As shown in Table 1.5, these

agreements not only set conservation targets but also provide funding, technical support, and monitoring mechanisms that enhance the resilience and management of Congo Basin PAs.

1.4.3 Regional Frameworks and Transboundary Conservation Initiatives

The Congo Basin's ecological integrity depends on cross-border cooperation because ecosystems and wildlife often span multiple jurisdictions. The main Congo Basin regional frameworks and transboundary conservation initiatives include the Central African Forests Commission (COMIFAC), transboundary conservation landscapes and the Economic Community of Central African States (ECCAS). The Central African Forests Commission (COMIFAC) was established in 2005 through the Yaoundé Declaration (1999), COMIFAC coordinates forest and environmental policies among Congo Basin countries. Its Convergence Plan prioritises PA expansion, climate adaptation, and transboundary management (Madzous et al., 2021). The Transboundary Conservation Landscapes are the Sangha Trinational (TNS) and TRIDOM (Tri-National Dja–Odzala–Minkébé) which are flagship examples of large-scale transboundary PA networks (**Table 1.6**). The TNS links Lobéké National Park (Cameroon), Dzanga-Sangha Reserve (Central African Republic), and the Nouabalé-Ndoki National Park (Republic of Congo). The TRIDOM connects PAs across Cameroon, Gabon, and Congo, covering ~178,000 km². The Economic Community of Central African States (ECCAS) promotes environmental cooperation and has endorsed the integration of PA management into climate change adaptation frameworks.

Table 1.6: Selected Transboundary PA Initiatives in the Congo Basin

Initiative	Participating Countries	Area (km²)	Objectives
Sangha Trinational (TNS)	Cameroon, CAR, Congo	~28,000	Biodiversity conservation, tourism, carbon storage
TRIDOM	Cameroon, Gabon, Congo	~178,000	Landscape connectivity, anti-poaching, REDD+
Lac Télé–Lac Tumba Landscape	Congo, DRC	~126,000	Peatland protection, fisheries management

Table 1.6 highlights key transboundary protected area (PA) initiatives in the Congo Basin that foster regional cooperation for conservation, climate mitigation, and sustainable resource use. The Sangha Trinational (TNS), involving Cameroon, the Central African Republic (CAR), and the Republic of Congo, spans approximately 28,000 km². Its primary objectives include biodiversity conservation, ecotourism development, and carbon storage through forest protection. The TRIDOM initiative (linking protected areas across Cameroon, Gabon, and Congo), covers a vast area of around 178,000 km². It focuses on enhancing landscape connectivity, combating poaching, and implementing REDD+ strategies to reduce emissions from deforestation. The third major initiative, the Lac Télé–Lac Tumba Landscape shared by Congo and the Democratic Republic of Congo (DRC), extends over roughly 126,000 km² and prioritizes the protection of extensive peatlands, crucial for carbon sequestration, as well as sustainable fisheries management. As shown in Table 1.6, these collaborative efforts not only safeguard critical ecosystems that span national borders but also address shared environmental challenges. They promote coordinated action on biodiversity, climate resilience, and community livelihoods, underscoring the importance of transboundary cooperation in maintaining the ecological integrity of the Congo Basin.

1.4.4 Policy Integration Challenges

Despite the formal frameworks, policy coherence is a major challenge owing to overlapping mandates between forestry, wildlife, and environmental ministries cause inefficiencies (Nago and Ongolo, 2021; Gakou-Kakeu et al., 2024); weak enforcement capacity undermines PA regulations,

especially in remote areas; and limited integration with climate policies as PAs feature in NDCs, but are often underfunded relative to infrastructure or agriculture.

The historical development of PAs in the Congo Basin reveals a shift from colonial-era preservationist models to contemporary, climate-integrated frameworks. International agreements have provided momentum and resources, while regional initiatives have enhanced cross-border collaboration. However, the full climate resilience potential of PAs remains constrained by governance fragmentation, funding shortages, and limited integration with broader development agendas.

1.5 Challenges to Protected Area Effectiveness

Protected areas (PAs) in the Congo Basin are indispensable for biodiversity conservation and climate resilience. However, their effectiveness is compromised by a range of ecological, socio-economic, and governance challenges. These pressures are not isolated; they interact in complex ways, exacerbating vulnerability to climate change and undermining the capacity of PAs to deliver on their conservation and adaptation mandates.

1.5.1 Pressures from Deforestation, Mining, Agriculture, and Infrastructure

While the Congo Basin remains the world's largest relatively intact tropical forest, deforestation rates are rising (Achille et al., 2021; Shapiro et al., 2021; Shapiro et al., 2022; Besisa Nguba et al., 2025). Drivers include shifting cultivation and expansion of subsistence agriculture; commercial agriculture for cocoa, oil palm, and rubber; illegal logging targeting high-value timber species; and charcoal production in peri-urban areas. Deforestation not only reduces biodiversity but also releases stored carbon, weakening the climate mitigation role of PAs (Adhikari et al., 2025). The region is rich in minerals such as cobalt, coltan, diamonds, and gold. Artisanal and industrial mining frequently occurs in or adjacent to PAs, leading to habitat destruction, water pollution from mercury and cyanide, and increased bushmeat hunting due to influx of miners (Nkuba, 2021; Verweijen et al., 2022). Roads, dams, and urban expansion fragment habitats, facilitate illegal resource extraction, and open up previously inaccessible areas (Laurance et al., 2017; Kleinschroth et al., 2019; Engert et al., 2025). For example, road construction through the TRIDOM landscape has accelerated logging and hunting pressures. Table 1.7 presents the major landuse pressures on protected areas in the Congo Basin.

Table 1.7: Key Land-Use Pressures on Congo Basin PAs

Pressure	Example Locations	Impacts
Agricultural expansion	Cocoa farms near Dja Reserve (Cameroon)	Forest conversion, edge effects
Logging	Buffer zones of Lobéké NP	Habitat loss, carbon emissions
Mining	Kahuzi-Biéga NP (DRC)	Pollution, wildlife disturbance
Infrastructure	Roads in TRIDOM landscape	Habitat fragmentation, poaching access

Table 1.7 outlines the key land-use pressures threatening protected areas (PAs) in the Congo Basin, highlighting the growing tension between conservation and development. Agricultural expansion, particularly near areas like the Dja Faunal Reserve in Cameroon, leads to forest conversion and edge effects, which degrade ecosystem integrity and increase human-wildlife conflict. Logging, often occurring in the buffer zones of Lobéké National Park, results in habitat loss and contributes to carbon emissions, undermining climate mitigation efforts. Mining activities, such as those in Kahuzi-Biéga National Park in the Democratic Republic of Congo (DRC), introduce pollutants and disturb wildlife, posing significant risks to both biodiversity and water quality. Infrastructure development (especially roads built across the TRIDOM landscape), fragments habitats and

facilitates illegal activities, including poaching and the bushmeat trade. As shown in Table 1.7, these land-use pressures directly threaten the ecological functions and conservation goals of PAs across the region. They also highlight the urgent need for integrated land-use planning, stricter enforcement, and community-based solutions to balance environmental protection with economic development in the Congo Basin.

1.5.2 Governance, Enforcement, and Financing Gaps

Governance, enforcement and financing gaps are major hurdles to the effectiveness of protected areas (Table 1.8). There is weak institutional capacity as PA management agencies often lack adequate staffing and training, equipment for patrolling and monitoring, and long-term financial sustainability. According to Wilkie et al. (2001) and Mukaku Kazadi et al. (2024), fewer than 30% of PAs in the region have management plans that are fully implemented. Enforcement challenges which can be observed in increasing poaching (driven by both subsistence needs and commercial demand e.g., ivory, bushmeat); corruption (illegal logging permits and poaching often facilitated by weak oversight); and conflict zones (armed conflict in parts of the DRC and CAR restricts ranger access). Funding shortfalls have equally hampered the effectiveness of protected areas in the Congo Basin. PA funding in the Congo Basin is heavily donor-dependent. Trust funds exist but are insufficient to cover operational costs. National budget allocations are often less than 1% of total PA needs (Walters and Wardell, 2023; Bush et al., 2024).

Table 1.8: PA Governance and Funding Gaps

Challenge	Implications	Example
Underfunding	Limited patrols, infrastructure decay	Salonga NP ranger shortages
Political instability	Disrupted management	Virunga NP during DRC conflicts
Corruption	Illegal exploitation within PAs	Timber concessions in protected zones

Table 1.8 highlights key governance and funding challenges facing protected areas (PAs) in the Congo Basin, which undermine their effectiveness and long-term sustainability. Underfunding is a major issue, resulting in limited patrol capacity, deteriorating infrastructure, and weak enforcement. For example, Salonga National Park in the Democratic Republic of Congo suffers from ranger shortages, reducing its ability to control poaching and illegal activities. Political instability further disrupts PA management, particularly in regions affected by conflict. In Virunga National Park, also in the DRC, ongoing insecurity has led to operational disruptions and threats to staff and wildlife. Corruption poses an additional threat by enabling illegal exploitation of natural resources within protected areas. A notable example is the allocation of timber concessions inside PA boundaries, undermining conservation goals and encouraging unsustainable practices. As detailed in Table 1.8, these challenges significantly weaken PA governance and increase vulnerability to external pressures such as poaching, logging, and land encroachment. Addressing these gaps requires increased, transparent funding, stronger legal frameworks, and improved political stability to ensure that protected areas in the Congo Basin can effectively fulfill their conservation and climate mitigation roles.

1.5.3 Social Conflicts and Community Engagement Issues

Social conflicts and community engagement issues have hampered the effectiveness of protected areas in the Congo Basin with the most prominent of these issues being historical displacement, livelihood trade-offs, benefit sharing deficits, and human-wildlife conflicts (Table 1.9). Colonial and post-independence PA establishment often excluded local communities from decision-making,

displacing them from ancestral lands (Simpson and Vuola, 2021; Simpson, 2022). This has fostered resentment and resistance to conservation measures. Restrictions on hunting, fishing, or farming within PAs can reduce access to subsistence resources, creating economic hardship unless alternative livelihoods are provided (Woodhouse et al., 2022). While eco-tourism and carbon finance have potential to generate revenue, benefits often fail to reach local communities equitably, eroding support for PAs. Expansion of elephant and gorilla ranges into farmland (sometimes driven by habitat shifts), results in crop losses and retaliatory killings (Tchamba, 1996; Maurice et al., 2023; Nampindo and Randhir, 2024; Matsuura et al., 2024).

Table 1.9: Social Dimensions of PA Challenges

Issue	Drivers	Consequences
Displacement	Colonial park creation	Loss of land rights, resentment
Livelihood restrictions	Hunting bans	Food insecurity, illegal resource use
Poor benefit-sharing	Weak governance	Reduced community cooperation
Human–wildlife conflict	Habitat encroachment	Crop damage, wildlife mortality

Table 1.9 examines the social dimensions of challenges faced by protected areas (PAs) in the Congo Basin, emphasizing how local communities are affected. One major issue is displacement, often a legacy of colonial-era park creation, which led to loss of land rights and ongoing resentment among displaced populations. Livelihood restrictions, particularly hunting bans within PAs, contribute to food insecurity for communities that rely on these resources, sometimes driving illegal resource use as a coping strategy. Poor benefit-sharing due to weak governance further undermines community support for conservation, resulting in reduced cooperation and engagement with PA management. Additionally, human–wildlife conflict arises from habitat encroachment as communities expand into protected zones, leading to crop damage and increased wildlife mortality. These conflicts negatively impact both people’s livelihoods and conservation goals. As outlined in Table 1.9, addressing these social challenges is essential for the sustainable management of Congo Basin PAs. It requires inclusive governance, equitable benefit-sharing, and strategies to mitigate human-wildlife conflicts to build trust and collaboration between local communities and conservation authorities.

1.5.4 Interactions Between Threats and Climate Change

Climate change magnifies existing pressures as droughts and crop failures can increase reliance on forest resources, intensifying illegal activities in PAs; habitat fragmentation reduces species’ ability to shift ranges in response to changing conditions; and increased flooding may damage PA infrastructure, limiting management effectiveness. Figure 1.3 presents the interactions between climate change and anthropogenic pressures in protected areas in the Congo Basin.

Figure 1.3 illustrates how natural and human-driven stressors converge to undermine conservation outcomes. The diagram highlights climate stressors, including rising temperatures, shifting rainfall patterns, and increasing frequency of extreme weather events, as primary drivers that interact with existing anthropogenic pressures. These climate-induced changes weaken ecosystem stability and increase the vulnerability of species and habitats within protected areas. From the climate stressors, the figure shows direct linkages to deforestation and poaching, which are already critical challenges in the Congo Basin. Deforestation, driven by agricultural expansion, logging, and fuelwood extraction, leads to habitat fragmentation and reduces carbon storage capacity. Climate variability exacerbates these impacts by increasing the risk of fire, altering species composition, and stressing forest regeneration. Similarly, poaching, primarily motivated by bushmeat demand and illegal wildlife trade, becomes more impactful when species populations are already stressed by changing climatic conditions. For instance, reduced food availability or water sources due to droughts can concentrate wildlife in limited areas, making them more susceptible to hunting pressure. At the center of these interactions lies governance weaknesses, a crucial amplifier of both climate and

anthropogenic pressures. Weak enforcement of conservation laws, insufficient resources for protected area management, and corruption allow deforestation and poaching to flourish despite formal protections. Climate stress further compounds governance challenges by increasing competition for land and resources, making enforcement more difficult and sometimes fueling local conflicts. Ultimately, the diagram converges on amplified impacts on protected areas, including habitat loss, biodiversity decline, and a weakening of ecosystem resilience. These outcomes not only threaten the ecological integrity of the Congo Basin but also reduce the adaptive capacity of local communities who depend on ecosystem services for livelihoods and climate resilience. The figure underscores the urgency of integrated strategies that simultaneously address climate adaptation, anti-poaching measures, sustainable land use, and stronger governance frameworks.

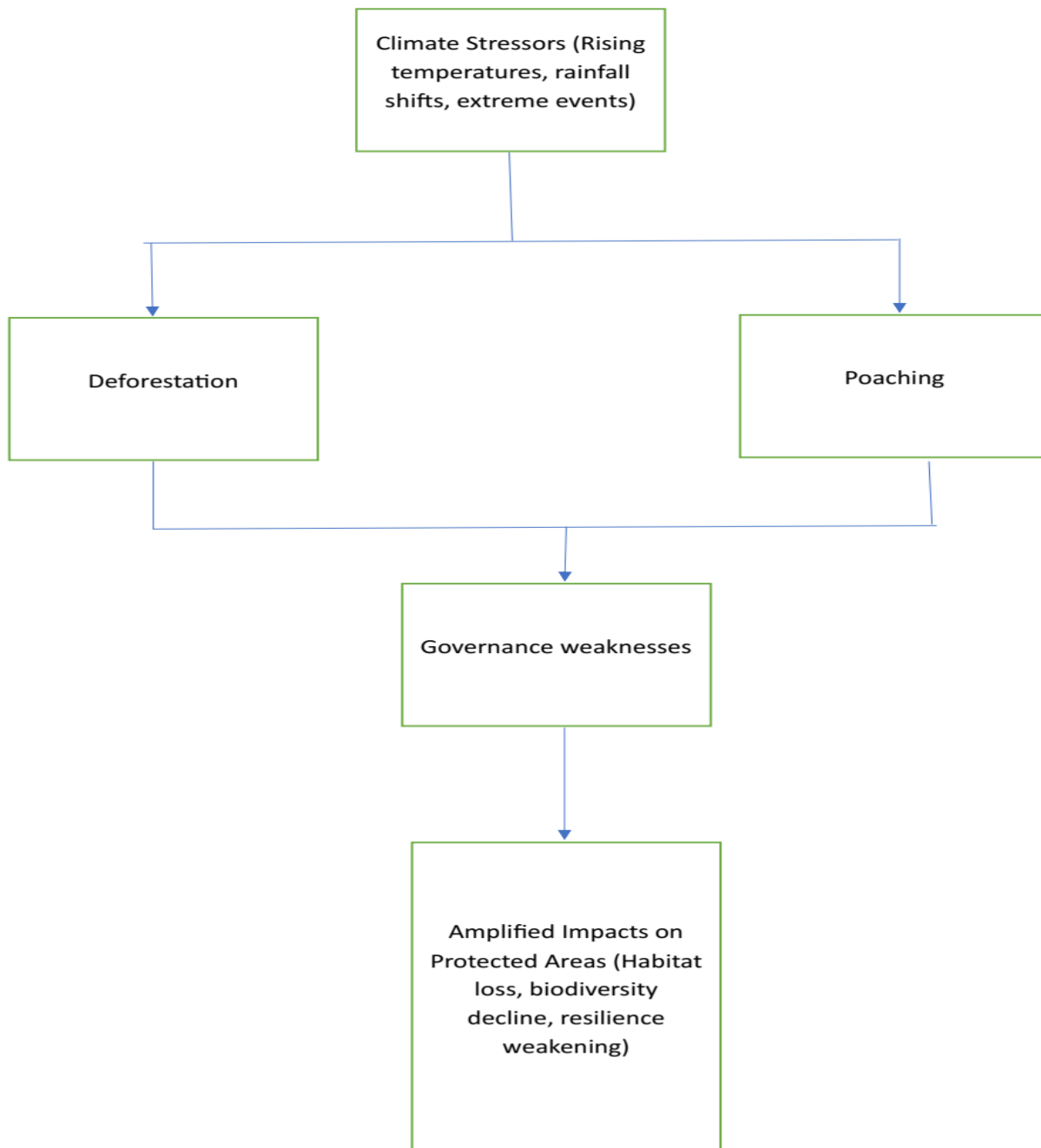


Figure 1.3: Interaction Between Climate Change and Anthropogenic Pressures

1.5.5 Addressing the Effectiveness Gap

Improving PA effectiveness requires the strengthening community co-management to integrate local knowledge and benefits; establishing sustainable financing mechanisms (e.g., conservation trust funds, payment for ecosystem services); enhancing law enforcement with technology (e.g., SMART patrols, drones); and integrating climate adaptation into PA management plans.

The challenges facing PAs in the Congo Basin are multifaceted and interlinked, spanning environmental degradation, institutional weaknesses, and socio-economic conflicts. These issues erode the ability of PAs to function as climate-resilient systems. Addressing them requires holistic, cross-sectoral strategies that integrate conservation, climate action, and community well-being.

1.6 Opportunities and Emerging Trends

While the Congo Basin's protected areas (PAs) face significant challenges, there are also emerging opportunities that can transform them into more effective tools for climate resilience, biodiversity conservation, and sustainable development. These opportunities lie in integrating PAs into broader climate planning, tapping into new green financing mechanisms, and leveraging technological innovations and data-driven management.

1.6.1 Integrating Protected Areas into Climate Adaptation and Mitigation Planning

Protected areas are integral to climate change adaptation and mitigation as they constitute an ecosystem-based approach and can be integrated into national climate policies in all countries in the Congo Basin (**Table 1.10**). Ecosystem-based adaptation (EbA) and mitigation (EbM) strategies are increasingly recognised in global policy frameworks as cost-effective ways to address climate risks (Bhattarai et al., 2021; Rawlins et al., 2023). Protected areas are central to these strategies because they safeguard ecosystem services such as carbon storage, water regulation, and disaster risk reduction. PAs can be incorporated into national adaptation plans (NAPs) to buffer communities against floods, droughts, and heatwaves. PAs can be included in nationally determined contributions (NDCs) under the Paris Agreement as measurable climate mitigation assets. Countries like Gabon and the Republic of Congo have begun integrating PA management into their national climate strategies. For example, Gabon's National Climate Plan explicitly recognises PAs as carbon sinks and sets targets for expanding the PA network to cover 30% of national territory (Bamwesigye and Yeboah, 2024).

Table 1.10: Examples of Policy Integration in the Congo Basin

Country	Policy Instrument	PA-related Climate Integration
Gabon	National Climate Plan (2021)	30% PA coverage goal, carbon sequestration accounting
Cameroon	Updated NDC (2021)	REDD+ in PA landscapes, EbA in buffer zones
DRC	NAP (2020)	Wetland and peatland PAs for flood mitigation
Republic of Congo	NDC (2021)	Peatland PAs in carbon market strategy

Table 1.10 presents examples of policy integration related to protected areas (PAs) and climate change in countries within the Congo Basin. Gabon's National Climate Plan (2021) includes an ambitious goal to cover 30% of the country with PAs, emphasizing their role in carbon sequestration accounting. Cameroon's Updated Nationally Determined Contribution (NDC) from 2021 highlights the integration of REDD+ initiatives within PA landscapes, alongside ecosystem-based adaptation (EbA) strategies in buffer zones to enhance climate resilience. The Democratic Republic of Congo's National Adaptation Plan (NAP) of 2020 focuses on using wetland and peatland PAs for flood mitigation, recognizing their importance in managing climate risks. Similarly, the Republic of

Congo's 2021 NDC incorporates peatland PAs into its carbon market strategy, aiming to leverage these ecosystems for emissions reductions and sustainable financing. As detailed in Table 1.10, these policy instruments demonstrate how Congo Basin countries are increasingly embedding climate change goals within PA management frameworks. This integration supports biodiversity conservation, enhances ecosystem services, and contributes to national and global climate commitments, reinforcing the multifunctional value of protected areas in the region.

1.6.2 Green Financing and Carbon Markets

The main green financing and carbon market mechanisms integrating protected areas in the Congo Basin include conservation trust funds, carbon credit mechanisms, and payment for ecosystem services (**Table 1.11**). Conservation Trust Funds which are dedicated trust funds can provide long-term, stable financing for PAs. For example, the Sangha Trinational Foundation (FTNS) supports TNS PAs through investment returns, reducing reliance on volatile donor cycles (Doinjashvili et al., 2021; Goué and Kana, 2023). Carbon credit mechanisms such as REDD+ and voluntary carbon markets allow PAs to monetise avoided deforestation and forest restoration. The Mai Ndombe REDD+ project in the DRC has generated millions of tonnes of verified carbon units (VCUs) while supporting community development (Koh et al., 2024). Peatland conservation projects in the Republic of Congo and the DRC are being piloted to access blue carbon finance. Payment for Ecosystem Services (PES) schemes where downstream water users pay upstream PA managers for maintaining water quality and flow could be developed, especially in hydrologically critical basins like the Ogooué and Congo rivers.

Table 1.11 Potential Green Financing Pathways

Mechanism	PA Benefit	Example in Region
Conservation Trust Funds	Stable long-term funding	FTNS for TNS landscape
REDD+ Carbon Credits	Monetise avoided emissions	Mai Ndombe project (DRC)
PES Schemes	Incentivise watershed protection	Pilot in Cross River Basin
Green Bonds	Infrastructure for sustainable tourism	Gabon ecotourism bond proposal

Table 1.11 outlines potential green financing pathways to support protected areas (PAs) in the Congo Basin, highlighting mechanisms that can provide sustainable funding while delivering conservation benefits. Conservation Trust Funds offer stable, long-term financial resources to ensure ongoing PA management. An example is the Fonds de Trust pour la Nature Sangha (FTNS), which supports the Sangha Trinational (TNS) landscape. REDD+ carbon credits enable the monetization of avoided greenhouse gas emissions by preserving forest carbon stocks. The Mai Ndombe project in the Democratic Republic of Congo exemplifies this approach by generating revenue through carbon markets. Payment for Ecosystem Services (PES) schemes incentivize the protection of critical ecosystems, such as watersheds, by compensating local communities or stakeholders. A pilot PES program in the Cross River Basin region demonstrates this strategy in practice. Lastly, Green Bonds provide financing for infrastructure projects that promote sustainable tourism and conservation. Gabon has proposed an ecotourism bond to fund infrastructure improvements while fostering eco-friendly economic development. As presented in Table 1.11, these green financing mechanisms offer diverse opportunities to mobilize resources, enhance PA management, and support both environmental and community goals in the Congo Basin, promoting a more sustainable and resilient future for the region.

1.6.3 Technology and Data-driven Conservation

Technological and data-driven conservation is a key opportunity and emerging trend sweeping across protected areas in the Congo Basin. The most prominent of these technology and data-driven conservation tools are remote sensing and GIS, SMART patrol systems, drone surveillance, and biodiversity eDNA monitoring. Satellite monitoring (e.g., Sentinel-2, Landsat) enables real-time detection of deforestation, illegal logging, and fire outbreaks in PAs (Tang et al., 2023; Santhosh, 2025; Ali et al., 2025). The Global Forest Watch platform has already been applied in parts of Cameroon and Gabon for rapid response. Spatial Monitoring and Reporting Tools (SMART) integrate GPS tracking, data logging, and analytics to enhance ranger patrol efficiency. SMART has been successfully deployed in Odzala-Kokoua National Park (Republic of Congo) to target poaching hotspots. Unmanned aerial vehicles can cover large, inaccessible areas quickly, aiding in wildlife counts, illegal activity detection, and mapping. Environmental DNA sampling from soil and water can provide low-cost, rapid biodiversity assessments, supporting adaptive PA management. Table 1.12 presents technology applications in protected areas in the Congo Basin.

Table 1.12: Technology Applications in Congo Basin PAs

Technology	Application	Example
Remote sensing	Deforestation alerts	Global Forest Watch Cameroon
SMART patrols	Anti-poaching	Odzala-Kokoua National Park
Drone mapping	Boundary enforcement	Dja Faunal Reserve
eDNA	Biodiversity monitoring	Sangha Trinational pilot

Table 1.12 highlights various technology applications being used to enhance the management and protection of protected areas (PAs) in the Congo Basin. Remote sensing technology, exemplified by Global Forest Watch in Cameroon, provides real-time deforestation alerts, enabling quicker responses to illegal logging and habitat loss. SMART patrols, which combine GPS, data collection, and analytics, are used for anti-poaching efforts, with Odzala-Kokoua National Park serving as a key example. This technology helps improve ranger efficiency and target enforcement actions more effectively. Drone mapping is another innovative tool, applied in areas like the Dja Faunal Reserve to assist in boundary enforcement by providing detailed aerial images, which help detect encroachment and illegal activities. Environmental DNA (eDNA) technology is being piloted in the Sangha Trinational landscape to monitor biodiversity by detecting genetic material from water or soil samples. This non-invasive method offers a powerful way to track species presence and ecosystem health. As detailed in Table 1.12, these technologies enhance monitoring, enforcement, and conservation efforts across the Congo Basin, improving the capacity to protect biodiversity and manage resources sustainably. They represent crucial advances in leveraging modern tools for effective PA governance in the region.

1.6.4 Strengthening Community-based Approaches

Strengthening community-based approaches is one of the key opportunities and emerging trends in protected areas across the Congo Basin. This is done through community conserved areas, livelihood integration, and co-management frameworks. Empowering local and indigenous communities to manage PAs or buffer zones can improve enforcement, strengthen cultural stewardship, and build resilience. Linking PA conservation with income-generating activities (such as sustainable NTFP harvesting, eco-tourism, and climate-smart agriculture), can enhance local support. Formal co-management agreements between government agencies and communities can ensure equitable benefit-sharing and conflict resolution.

1.6.5 Transboundary and Regional Cooperation

Transboundary and regional cooperation are another vital opportunity and emerging trend in protected areas management in the Congo Basin. Regional initiatives like COMIFAC's Convergence Plan and ECCAS' climate framework create opportunities for harmonised policies on anti-poaching; shared databases for biodiversity and climate monitoring; and joint applications for climate finance.

1.6.6 Linking to Global Initiatives and Targets

Protected areas in the Congo Basin are also increasingly liaising with global initiative and targets. The post-2020 Global Biodiversity Framework's "30x30" target (to protect 30% of land and sea by 2030) offers both political momentum and potential funding. Congo Basin countries can align PA expansion with this goal while securing climate co-benefits.

Despite the serious challenges facing Congo Basin PAs, there is an unprecedented convergence of opportunities. Integrating PAs into climate strategies, unlocking green finance, and harnessing technology can transform these landscapes into powerful climate-resilient systems. The key lies in scaling successful pilots, fostering cross-border cooperation, and ensuring that local communities are both partners and beneficiaries in conservation.

1.7 Rationale for the Book

The Congo Basin, as the world's second-largest tropical rainforest, is at a critical crossroads. The interplay between climate change, biodiversity loss, and socio-economic pressures makes it one of the most important yet vulnerable ecosystems on the planet. The preceding sections of this chapter have shown that protected areas (PAs) can be powerful instruments for both climate mitigation and adaptation, but their potential is far from fully realised. This book was conceived to bridge the gap between policy, science, and practice in designing and managing PAs for a climate-resilient future in the Congo Basin.

1.7.1 Bridging the Knowledge Gap Between Policy, Science, and Practice

While there is abundant research on climate change impacts in the Congo Basin and significant policy commitments to conservation, there is often a disconnect between scientific evidence, policy implementation, and on-the-ground realities. Research by Reiche et al. (2021), Majambu et al. (2021), Atyi (2022), and Mukaku Kazadi et al. (2024) has provided a strong evidence base on the role of Congo Basin forests in carbon storage, biodiversity conservation, and hydrological regulation. However, these findings often remain within academic or donor project circles. Instruments like the Convention on Biological Diversity (CBD), the Paris Agreement, and COMIFAC's Convergence Plan include provisions for PA strengthening. Yet, national-level implementation is uneven, and climate-conservation integration is often superficial. PA managers and local communities face daily realities of limited resources, governance challenges, and competing land-use demands that are rarely addressed adequately in policy documents. This book aims to close these gaps by synthesising scientific research on the climate-PA nexus in the Congo Basin, analysing policy frameworks to identify enablers and bottlenecks, documenting case studies of practical PA management innovations, and providing actionable recommendations that bridge scales, from local to global.

1.7.2 Importance of Integrated Landscape Approaches

Traditional conservation strategies have often treated PAs as ecological islands, focusing on protection within fixed boundaries. However, climate change challenges this model. As species shift ranges, rainfall patterns change, and ecosystems transform, PA boundaries alone cannot safeguard biodiversity and ecosystem services. An integrated landscape approach is needed, one that connects