



## Socio-ecological dynamics and anthropogenic pressures on tropical peatland ecosystems: the case of Lokolama and Mpenzele villages (Bikoro Territory, Democratic Republic of the Congo)

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### RESUME

**Description of the subject.** The peatlands of the Congo Basin represent one of the largest terrestrial organic carbon reservoirs globally and play a critical role in climate regulation, biodiversity conservation, and the livelihoods of surrounding communities.

**Objective.** This study assesses socio-economic dynamics and anthropogenic pressures affecting peatland ecosystems in the villages of Lokolama and Mpenzele, located in the Bikoro Territory of the Democratic Republic of the Congo.

**Methods.** A mixed-methods approach was employed, combining field observations, socio-economic household surveys, focus group discussions, and spatial analysis using Geographic Information Systems (GIS).

**Results.** The results indicate that local livelihoods are predominantly based on agriculture (35 %), followed by fishing (16 %), non-timber forest product harvesting (14 %), hunting (11 %), artisanal activities (10 %), cassava retting (8 %), and the extraction of construction materials (6 %). Comparative analysis reveals a higher diversification of livelihood activities in Lokolama than in Mpenzele, indicating greater socio-economic resilience. However, the expansion of agricultural land and intensified exploitation of natural resources are exerting increasing pressure on peatland ecological integrity, with potential risks of hydrological disturbance and enhanced greenhouse gas emissions.

**Conclusion.** These findings emphasize the need for sustainable management strategies that integrate indigenous knowledge systems, ecosystem conservation, and the socio-economic needs of local populations in order to ensure the long-term sustainability of peatland ecosystem services.

**Keywords:** Tropical peatlands, Congo Basin, socio-ecological dynamics, natural resource exploitation, Democratic Republic of the Congo.

### RESUME

**Dynamiques socio-écologiques et pressions anthropiques sur les écosystèmes de tourbières tropicales : le cas des villages Lokolama et Mpenzele (Territoire de Bikoro, République démocratique du Congo)**

**Description du sujet.** Les tourbières du Bassin du Congo constituent l'un des plus grands réservoirs terrestres de carbone organique au monde et jouent un rôle essentiel dans la régulation du climat, la conservation de la biodiversité ainsi que le maintien des moyens de subsistance des communautés riveraines.

**Objectif.** Cette étude évalue les dynamiques socio-économiques et les pressions anthropiques qui affectent les écosystèmes de tourbières dans les villages de Lokolama et de Mpenzele, situés dans le territoire de Bikoro, en République démocratique du Congo.

**Méthodes.** Une approche méthodologique mixte a été adoptée, combinant des observations de terrain, des enquêtes socio-économiques auprès des ménages, des discussions de groupes (focus groups) ainsi qu'une analyse spatiale à l'aide d'un Système d'Information Géographique (SIG).

**Résultats.** Les résultats montrent que les moyens de subsistance des populations locales reposent principalement sur l'agriculture (35 %), suivie de la pêche (16 %), de la collecte des produits forestiers non ligneux (14 %), de la chasse (11 %), des activités artisanales (10 %), du rouissage du manioc (8 %) et de l'extraction des matériaux de

construction (6 %). L'analyse comparative met en évidence une plus grande diversification des activités de subsistance à Lokolama qu'à Mpenzele, traduisant une meilleure résilience socio-économique. Toutefois, l'extension des terres agricoles et l'intensification de l'exploitation des ressources naturelles exercent une pression croissante sur l'intégrité écologique des tourbières, avec des risques potentiels de perturbation du régime hydrologique et d'augmentation des émissions de gaz à effet de serre.

**Conclusion.** Ces résultats soulignent la nécessité de mettre en œuvre des stratégies de gestion durable intégrant les savoirs locaux, la conservation des écosystèmes et les besoins socio-économiques des populations riveraines, afin d'assurer la pérennité des services écosystémiques fournis par les tourbières.

**Mots-clés :** Tourbières tropicales, Bassin du Congo, dynamiques socio-écologiques, exploitation des ressources naturelles, République démocratique du Congo.

## 1. INTRODUCTION

Peatlands are among the most important wetland ecosystems on Earth, accounting for nearly 50% of all global wetland areas (Ramsar Convention, 2018). They cover approximately 400 million hectares, representing about 3% of the Earth's land surface, while storing nearly 30% of the world's soil organic carbon (Ramsar, 2021; Rosset *et al.*, 2023). This exceptional carbon storage capacity gives peatlands a strategic role in global climate regulation and in mitigating the effects of climate change.

Peatlands form through the gradual accumulation of partially decomposed organic matter under permanently waterlogged and oxygen-poor conditions. These conditions significantly slow down mineralization processes, allowing peat to accumulate over centuries or even millennia. The resulting peat layers can reach several meters in thickness and contain large amounts of long-term sequestered carbon (Joosten & Clarke, 2002; Parish *et al.*, 2008).

Over recent decades, research has demonstrated that tropical peatlands constitute particularly important carbon reservoirs. The vast peat complexes of the Congo Basin, recently discovered and mapped, represent the largest tropical peatland complex in the world. These peatlands cover approximately 145,500 km<sup>2</sup> and are estimated to store nearly 29–30 billion tonnes of carbon, equivalent to several years of global fossil fuel emissions (Dargie *et al.*, 2017; Crezee *et al.*, 2022). This discovery has significantly increased scientific and policy interest in the conservation of African tropical peatlands.

Tropical peatlands provide multiple ecosystem services essential to human well-being and the stability of natural systems. In addition to their fundamental role in carbon sequestration, they actively regulate hydrological cycles by storing large volumes of water, recharging groundwater systems, sustaining river flows during dry periods, and reducing flood risks during heavy rainfall events (Xu *et al.*, 2018; Diana *et al.*, 2022). Their filtration capacity also contributes to water quality

improvement by trapping sediments, nutrients, and certain contaminants.

Ecologically, peatlands host remarkable biodiversity characterized by highly specialized plant and animal species adapted to these unique hydrological conditions. In the Congo Basin, they provide essential habitats for numerous species of mammals, birds, fish, amphibians, and invertebrates, some of which are endemic or threatened with extinction. These ecosystems therefore play a significant role in maintaining regional and global biodiversity (Roucoux *et al.*, 2017; Crezee *et al.*, 2022).

Peatlands also possess exceptional scientific value. Due to continuous organic matter accumulation and limited decomposition, they act as natural archives preserving pollen, spores, charcoal particles, plant remains, and other paleoenvironmental indicators. These records provide valuable insights into past climate evolution, landscape dynamics, vegetation changes, and human activities over thousands of years (Bernard, 2016; Swindles *et al.*, 2019). They thus represent a key tool for understanding long-term environmental change.

Furthermore, local populations depend heavily on peatland resources for their livelihoods. These ecosystems provide fuelwood, non-timber forest products, fishery resources, and land for traditional agricultural practices. Economic activities associated with peatlands may occur in situ, such as agriculture on organic soils, fishing, or resource harvesting, or ex situ through peat extraction used as fuel, soil amendment, or raw material in various industries (Joosten, 2015).

Despite their ecological and socio-economic importance, peatlands are among the most threatened ecosystems globally. Their degradation is mainly driven by human activities such as drainage, agricultural expansion, logging, peat extraction, infrastructure development, and mining. These disturbances alter natural hydrological regimes, accelerate organic matter decomposition, and lead to significant greenhouse gas emissions,

particularly carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) (Campbell *et al.*, 2014; IPCC, 2022).

The degradation of tropical peatlands is now a major concern in the context of climate change mitigation. According to recent estimates by the Intergovernmental Panel on Climate Change (IPCC), drained and degraded peatlands represent a disproportionately large source of greenhouse gas emissions relative to their limited surface area. Their conservation is now recognized as one of the most effective nature-based solutions for achieving carbon neutrality and preserving essential ecosystem services (IPCC, 2022; UNEP, 2023).

In the Congo Basin, which hosts some of the world's largest tropical peat reserves, knowledge regarding local exploitation practices and their environmental impacts remains limited. A better understanding of community practices, anthropogenic pressures, and sustainable management mechanisms is therefore essential to reconcile the socio-economic needs of local populations with the conservation requirements of these strategic ecosystems.

The objective of this study is to promote sustainable local practices for the exploitation and management of peatlands in order to preserve their ecological functions, maintain the livelihoods of surrounding communities, and contribute to climate change mitigation.

## 2. MATERIAL AND METHODS

### 2.1. Study area: Lokolama and Mpenzele villages

The villages of Lokolama and Mpenzele are located in the Bofidji West group, Elanga sector, Bikoro Territory, in the province of Équateur, Democratic Republic of the Congo. They are situated approximately 55 km from the city of Mbandaka along National Road No. 8 (RN8).

The study area covers an estimated surface of 42,299 hectares and forms part of the vast central Congo Basin peatland complex. This region is of major ecological importance due to its significant organic carbon stocks, high biodiversity, and the wide range of ecosystem services it provides to local communities.

#### Geographic location

The villages of Lokolama and Mpenzele are located within the Bofidji West grouping of the Elanga sector. Geographically, they are bounded by the village of Ilanga to the north, and the village of Bempaka to the south. To the east, the territory extends into a vast wetland area dominated by peat formations, while to the west, it is delimited by the

Congo River, which constitutes a major natural boundary.

#### Land use and land cover

Land use is mainly dominated by swamp forests and peatland formations. Spatial analyses based on Landsat satellite imagery allowed the identification of several land cover units, including primary forests, secondary forests, aquatic zones, agricultural areas, and anthropized surfaces.

### 2.2. Biophysical characteristics of the environment

#### Soils and relief

The villages of Lokolama and Mpenzele are characterized by a generally flat to gently undulating relief, typical of the equatorial lowlands of the Congo Basin. A few low hills occur locally but have limited influence on the overall landscape morphology. Soils are mainly clayey and hydromorphic. Their high water retention capacity supports agricultural and livestock activities practiced by local populations. During the rainy season, several areas become difficult to access due to the expansion of marshlands and soil waterlogging (Elanga Sector Archives, 2022).

#### Vegetation

Vegetation is heavily dominated by swamp forests, which account for approximately 84.0 % of the vegetative cover within the study area. Additionally, mature secondary forests, swamp grasslands along the Congo River, and fallows in the northeastern zone are also present. The flora exhibits high species diversity, with a marked dominance of plant families such as Fabaceae, Euphorbiaceae, Meliaceae, Myristicaceae, Sapotaceae, Annonaceae, and Rubiaceae. This floristic richness underscores the high ecological value of the studied peatland ecosystems.

#### Climate

The villages of Lokolama and Mpenzele are located near the Equator and experience a humid tropical climate (Af) according to the Köppen–Geiger classification. Mean annual temperatures range between 21 °C and 31 °C, while rainfall is abundant and well-distributed throughout the year. The regional climate is characterized by two distinct periods, namely a long rainy season spanning from September to April, and a relatively dry season extending from May to August. These bioclimatic conditions favor the development of perennial crops such as rubber (*Hevea brasiliensis*), oil palm (*Elaeis guineensis*), coffee (*Coffea* spp.), and cocoa (*Theobroma cacao*), alongside various food crops (FONAREDE, 2023).

## Hydrology

The study area is characterized by a dense hydrological network composed of rivers, streams, and wetlands connected to the Congo River. These water bodies play a fundamental role in supporting artisanal fishing activities, facilitating the transport of people and agricultural products, and driving commercial exchanges with the urban centers of Mbandaka, Bikoro, and Lukolela. Although navigable, many of these waterways lack regular maintenance (Elanga Sector Archives, 2022).

## 2.3. Socio-demographic characteristics

The population of Mpenzele is mainly composed of Bantu communities belonging to the Mongo (Nkundo) ethnic group, whereas the village of Lokolama is predominantly inhabited by the indigenous Batwa population, who nevertheless represent a demographic minority across the region.

## 2.5. Research material

### Biological material

The biological material consisted of botanical samples collected in peatland areas. The specimens were dried, preserved as herbarium samples, and identified at the Herbarium of the Faculty of Sciences, University of Kinshasa (UNIKIN).

### Non-biological materials

The materials used for data collection included (Table 1).

**Table 1.** Materials used for data collection

| No. | Material             | Purpose                                          |
|-----|----------------------|--------------------------------------------------|
| 1   | Field notebook       | Note-taking and field observations               |
| 2   | Pen                  | Recording collected information                  |
| 3   | Survey questionnaire | Collection of socio-economic data                |
| 4   | Canon digital camera | Photographic documentation                       |
| 5   | Garmin MAP 64s GPS   | Georeferencing points of interest                |
| 6   | Itel mobile phone    | Recording interviews and focus group discussions |

## 2.6. Methods

### Methodological approach

This study is based on a mixed-methods approach, combining both qualitative and quantitative techniques. Primary and secondary data were gathered through direct observation, individual household surveys, focus group discussions, documentary research, and geospatial analysis.

### Direct observation

Direct observation facilitated the identification of various forms of peatland exploitation, notably subsistence agriculture, artisanal fishing, cassava retting, and the collection of non-timber forest products. Additionally, this approach allowed for the documentation of construction wood harvesting

The primary languages spoken include Mongo, Tswa, and Lingala, the latter serving as the lingua franca. Local livelihoods heavily rely on subsistence agriculture, artisanal fishing, hunting, the harvesting of non-timber forest products, and small-scale natural resource exploitation.

## 2.4. Socio-economic infrastructure

Social infrastructure remains highly limited across both study sites. Mpenzele village is equipped with two primary schools, two secondary schools, a single health center, and a football field, while being intersected by National Road No. 8, which connects Mbandaka to the Bikoro Territory. Conversely, the infrastructure in Lokolama village is critically deficient, primarily consisting of a single primary school constructed from adobe bricks and sheltered by a thatched roof (Personal communication from the village chief, 2022).

alongside traditional natural resource management practices.

### Socio-economic surveys

A semi-structured questionnaire was administered to selected households across both villages. The surveys specifically addressed peatland exploitation practices, extracted resources, local ecological knowledge, and community perceptions regarding ecosystem conservation. Furthermore, data collection was actively supported by customary authorities, local community leaders, and representatives from the provincial environmental administration.

### Focus group discussions

Three focus group discussions were conducted in each village, targeting distinct demographic cohorts, namely elders, women, and youth. Each

focus group comprised 7 to 12 participants. The discussions primarily addressed local perceptions of peatlands (Amba Lontoku), traditional exploitation practices, and community-based conservation strategies. Each session lasted approximately one hour and was systematically documented through detailed note-taking and digital audio recordings.

### Spatial analysis and data processing

Geospatial analyses were performed using ArcGIS 10.8 and IDRISI TerrSet software. Landsat 7 and Landsat 8 satellite imagery were mobilized to map land use and land cover, calculate vegetation indices, delineate peatland areas, and quantify levels of anthropogenic pressure. The different land use and land cover classes identified include primary forest, secondary forest, wetland, water bodies, bare soil, and anthropized areas. Statistical data were processed using Microsoft Excel, while manuscript preparation was completed using Microsoft Word.

## 3. RESULTS

### 3.1. Structure of peatland exploitation activities in the villages of Mpenzele and Lokolama

Surveys conducted among peatland users identified seven main categories of activities carried out within the peatland ecosystems of Lokolama and Mpenzele. These activities include agriculture, fishing, the collection of non-timber forest products (NTFPs), hunting, artisanal activities, cassava retting, and the harvesting of construction materials (Table 3).

**Table 3.** Comparative distribution of peatland users

| Activity               | Mpenzele (n=50) | %          | Lokolama (n=50) | %          | Total      | Global %   |
|------------------------|-----------------|------------|-----------------|------------|------------|------------|
| Agriculture            | 20              | 40         | 15              | 30         | 35         | 35         |
| Fishing                | 8               | 16         | 8               | 16         | 16         | 16         |
| NTFP collection        | 7               | 14         | 7               | 14         | 14         | 14         |
| Hunting                | 5               | 10         | 6               | 12         | 11         | 11         |
| Artisanal activities   | 4               | 8          | 6               | 12         | 10         | 10         |
| Cassava retting        | 4               | 8          | 4               | 8          | 8          | 8          |
| Construction materials | 2               | 4          | 4               | 8          | 6          | 6          |
| <b>Total</b>           | <b>50</b>       | <b>100</b> | <b>50</b>       | <b>100</b> | <b>100</b> | <b>100</b> |

The results reveal a strong dependence of local populations on peatland resources. Agriculture is the dominant activity in both villages, with a global frequency of 35%, representing more than one-third of all recorded uses. Fishing ranks second with 16 % of users, while NTFP collection accounts for 14%. Together, these three activities represent 65 % of the overall observed economic activities.

This situation highlights the importance of peatlands as a key source of food security and income for rural populations in the Bikoro territory.

### 3.2. Comparative statistical analysis between the two villages

To compare the socio-economic characteristics of the two study villages, the relative contribution of each livelihood activity was analyzed. Table 4 presents the distribution of the main income-generating and subsistence activities in Lokolama and Mpenzele, highlighting similarities and differences in livelihood strategies between the two communities.

**Table 4.** Relative contribution of activities to local livelihoods

| Activities  | Contribution (%) |
|-------------|------------------|
| Agriculture | 35               |
| Fishing     | 16               |

### 2.7. Sampling criteria for peatland exploiters

The study sample comprised men and women actively involved in the exploitation of peatland resources across the villages of Mpenzele and Lokolama. Participant selection criteria were established based on gender, age, marital status, the depth of local ecological knowledge regarding peatlands, and years of experience in natural resource harvesting. The results indicate that men account for 62.0 % of the exploiters, compared to 38.0 % for women. Married individuals represent the dominant demographic category (72.0 %), followed by single individuals (23.0 %), widows or widowers (4.0 %), and divorced individuals (1.0 %). Regarding the transmission of local knowledge, older respondents generally exhibit a higher level of expertise (51.0 %) than younger generations (49.0 %), an asymmetry primarily attributable to their extensive experience in the traditional and customary use of these ecosystems.

|                      |    |
|----------------------|----|
| NTFPs                | 14 |
| Hunting              | 11 |
| Artisanal activities | 10 |
| Cassava retting      | 8  |
| Construction         | 6  |

The analysis shows a clear hierarchy of activities. Indeed, 65% of local livelihoods depend on only three main activities. This concentration indicates a potential vulnerability of communities to environmental changes that may affect agricultural, fishery, and forest resources.

### 3.3. Diversity of exploitation activities

To assess livelihood diversification, the Shannon diversity index ( $H'$ ) was calculated (Table 5).

**Table 5.** Diversity of exploitation activities

| Village  | $H'$ (Shannon) |
|----------|----------------|
| Mpenzele | 1.68           |
| Lokolama | 1.82           |

The results show that Lokolama exhibits a slightly higher diversity index than Mpenzele. This suggests that households in Lokolama distribute their activities across a broader range of income sources, whereas those in Mpenzele remain highly dependent on agriculture.

Higher diversification is generally considered a key factor of resilience to ecological and economic disturbances.

### 3.4. Anthropogenic pressure on peatlands

The recorded activities were classified according to their potential level of impact on peatland ecosystems (Table 6).

**Table 6.** Classification of activities according to ecological pressure

| Pressure level    | Activities concerned                              |
|-------------------|---------------------------------------------------|
| High pressure     | Agriculture, harvesting of construction materials |
| Moderate pressure | Fishing, hunting                                  |
| Low pressure      | NTFPs, traditional artisanal activities           |
| Variable          | Cassava retting                                   |

Agricultural activities appear to be the main potential drivers of ecological disturbance. The opening of new farmland often requires vegetation clearing and locally alters the hydrological functioning of peatlands.

### 3.5. Analysis of local ecological knowledge

Individual interviews and focus group discussions revealed a profound local understanding of peatland ecosystems. Respondents commonly refer to these environments using the traditional term “Amba Lontoku” and recognize several critical functions, including water conservation, wildlife habitat provisioning, fish availability, soil fertility maintenance, the supply of construction materials, and local climate regulation. Furthermore, elderly respondents demonstrate a significantly more detailed comprehension of peatland ecological functioning than younger generations.

### 3.6. Socio-economic importance of peatlands

Overall analysis shows that peatlands play a central role in the local economy (Table 7).

**Table 7.** Main ecosystem services identified

| Service                | Level of importance (%) |
|------------------------|-------------------------|
| Food production        | 92                      |
| Monetary income        | 85                      |
| Fish resources         | 81                      |
| Forest products        | 78                      |
| Construction materials | 65                      |
| Cultural values        | 61                      |

Provisioning services largely dominate the benefits derived from peatlands. This trend is consistent with observations in other regions of the Congo Basin, where rural populations heavily depend on natural resources for their daily livelihoods.

#### 4. DISCUSSION

The results of this study highlight the fundamental role played by the peatlands of Lokolama and Mpenzele in the functioning of local socio-ecological systems. The full range of recorded activities demonstrates that these ecosystems are not only biodiversity-rich natural areas but also productive landscapes that directly support the livelihoods of surrounding populations. The observed interactions between local communities and peatland resources reflect a strong economic, food-related, and cultural dependence, which is characteristic of many communities living in tropical wetland environments of the Congo Basin.

Agriculture emerges as the dominant activity in both studied villages, accounting for 40% of users in Mpenzele and 30 % in Lokolama. This predominance confirms the importance of the productive function of peatlands in rural household livelihood strategies. Peatland organic and hydromorphic soils are generally perceived by local communities as fertile lands suitable for the cultivation of cassava, maize, plantain, and other staple crops. Similar situations have been reported in several tropical regions of Central Africa, where peatlands constitute important land reserves under increasing demographic pressure and declining availability of arable land (Dargie *et al.*, 2017; Crezee *et al.*, 2022).

However, while agriculture contributes significantly to local food security, it also represents one of the main potential drivers of peatland degradation. Several studies have shown that the conversion of swamp forests into agricultural land profoundly alters the hydrological characteristics of peatlands. Vegetation clearing increases evapotranspiration, reduces soil water retention capacity, and accelerates the decomposition of accumulated organic matter. These disturbances can lead to a progressive loss of soil organic carbon stocks and increase greenhouse gas emissions, particularly carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>), thereby contributing to global climate change (Joosten & Clarke, 2002; IPCC, 2022).

Fishing and the collection of non-timber forest products (NTFPs) represent the second and third most important exploitation activities in both villages, respectively accounting for nearly 30% of recorded activities. This importance reflects the biological richness of the studied wetland ecosystems and their contribution to local food

security. Fish resources constitute a key source of animal protein, while NTFPs provide food, medicinal, energy, and artisanal products essential to household economies.

These findings are consistent with those reported in other peatland areas of the Congo Basin, where local communities derive a significant share of their income from artisanal fishing, wild fruit harvesting, medicinal plants, rattan, and other forest resources (Roucoux *et al.*, 2017; Tiemoko *et al.*, 2021). In contrast to extensive agriculture, these forms of exploitation are generally considered less destructive when practiced at low intensity and may therefore represent viable alternatives for sustainable peatland management strategies.

The study also reveals notable differences between Mpenzele and Lokolama regarding the structure of economic activities. Lokolama exhibits a more balanced distribution of livelihood activities, with relatively higher participation in hunting, artisanal work, and construction material collection. This diversification is reflected in a higher Shannon index, indicating greater livelihood diversity.

This pattern may be associated with the presence of Indigenous Batwa communities, whose subsistence systems are traditionally based on diversified natural resource use. Numerous studies have shown that Indigenous peoples often develop resource-use strategies grounded in detailed ecological knowledge and livelihood diversification, which helps reduce risks associated with environmental variability (Levis *et al.*, 2021; FAO, 2023). Such diversification constitutes a major factor of socio-ecological resilience in contexts exposed to climatic and economic uncertainty.

The analysis of local ecological knowledge further reveals a strong understanding of peatland characteristics among local communities. Respondents recognize the hydrological, productive, and ecological functions of peatlands and possess traditional knowledge related to their use and management. Elderly people appear to be the main holders of this knowledge, highlighting the importance of intergenerational knowledge transmission.

Local knowledge is now widely recognized as a key lever for tropical peatland conservation. Several international wetland management programs acknowledge that purely technocratic approaches often yield limited outcomes when they fail to integrate local knowledge and practices (UNEP, 2023). The integration of Indigenous knowledge into conservation strategies could therefore improve the effectiveness of peatland management policies in the Congo Basin.

Furthermore, hunting activities observed in both villages highlight the importance of peatlands as

wildlife habitats. Swamp forests serve as critical refuges for numerous species of mammals, birds, and reptiles. However, increasing hunting pressure could threaten local biodiversity and disrupt ecosystem functioning. This issue is particularly concerning in the Congo Basin, where several iconic species are already affected by combined pressures of habitat loss and overexploitation (IUCN, 2024).

From an ecological perspective, the results confirm that the peatlands of Lokolama and Mpenzele play a key role in carbon storage and local hydrological regulation. The extensive swamp forests dominating both sites contribute to soil stabilization, water filtration, and biodiversity maintenance. These ecosystem functions are particularly important in the context of climate change, where peatlands are recognized as critical natural infrastructures for greenhouse gas mitigation.

Recent estimates in the Congo Basin suggest that central African peatlands store nearly 30 billion tons of organic carbon, equivalent to several years of global fossil fuel carbon emissions (Dargie *et al.*, 2017; Crezee *et al.*, 2022). Any significant degradation of these ecosystems could therefore have environmental consequences far beyond the local scale.

Finally, the results underline the need for integrated management models that reconcile ecological conservation with socio-economic development. The strong dependence of local populations on peatland resources makes strict exclusion-based protection measures difficult to implement. A more realistic approach would involve participatory management mechanisms that actively engage communities in planning, monitoring, and conservation processes.

Such approaches could include the development of hydromorphic-adapted agroforestry systems, sustainable valorization of non-timber forest products, promotion of alternative income-generating activities, and strengthening of local capacities in natural resource management. These measures would not only contribute to the preservation of peatland ecological functions but also improve the livelihoods of dependent communities.

Overall, this study demonstrates that the peatlands of Lokolama and Mpenzele are strategic ecosystems whose conservation is inseparable from the sustainable development of local communities. Their future management must necessarily integrate ecological, social, economic, and cultural dimensions to ensure the long-term maintenance of ecosystem services at local, national, and global scales.

## 5. CONCLUSION

The results of this study show that the peatlands of Lokolama and Mpenzele are essential ecosystems supporting the livelihoods of local populations. The main recorded activities agriculture, fishing, collection of non-timber forest products, hunting, and artisanal activities demonstrate the strong dependence of communities on the natural resources provided by these wetland environments.

Comparative analysis reveals that agriculture remains the dominant activity in both villages, while other forms of exploitation contribute to livelihood diversification and strengthen household socio-economic resilience. However, the intensification of certain activities, particularly agricultural expansion and forest resource extraction, may exert increasing pressure on the ecological integrity of peatlands.

Moreover, traditional ecological knowledge held by local communities represents an important asset for ecosystem conservation. Its integration into sustainable management strategies is essential to reconcile environmental conservation objectives with the socio-economic needs of riparian populations.

Thus, the sustainability of the Lokolama and Mpenzele peatlands will depend on the implementation of participatory and integrated management approaches that simultaneously promote the conservation of ecological functions, the maintenance of carbon stocks, and the sustainable improvement of local livelihoods.

Further studies are required to quantify the long-term impacts of anthropogenic activities on peatland carbon dynamics, hydrological processes, biodiversity, and ecosystem services, while assessing the effectiveness of sustainable management strategies under changing environmental and socio-economic conditions.

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## Références

- Bernard J., 2016. *Les tourbières : fonctionnement, biodiversité et conservation*. Versailles : Éditions Quae, 220 p.
- Campbell D., Lavoie C. & Rochefort L., 2014. The impact of peat extraction on peatland ecosystems and restoration challenges. *Mires and Peat*, 13, 1–15.
- Convention on Wetlands (Ramsar Convention Secretariat), 2018. *Global Wetland Outlook: State of the World's Wetlands and Their Services to People*. Gland, Switzerland : Secretariat of the Convention on Wetlands, 88 p.
- Crezee B., Dargie G. C., Ewango C. E. N. et al., 2022. Mapping peat thickness and carbon stocks of the central Congo Basin. *Nature Geoscience*, 15(8), 639–644. <https://doi.org/10.1038/s41561-022-00966-7>
- Couclétis H. 1992. People manipulate objects (but cultivate fields) : Beyond the raster-vector debate in GIS. In A. U. Frank, I. Campari, & U. Formentini (Eds.). *Theories and methods of spatio-temporal reasoning in geographic space*, pp. 65–77. Dargie G. C., Lewis S. L., Lawson I. T., Mitchard E. T. A., Page S. E., Bocko Y. E. & Ifo S. A., 2017. Age, extent and carbon storage of the central Congo Basin peatland complex. *Nature*, 542(7639), 86–90. <https://doi.org/10.1038/nature21048>
- Diana M., Johnson P. & Smith R., 2022. Peatlands and ecosystem services in tropical regions. *Wetlands Ecology and Management*, 30(4), 555–571. El-Masri S. & Kaufmann V., 2006. Geographic information systems and environmental management applications. *Environmental Modelling & Software*, 21(6), 815–826.
- ENABEL, 2022. *Étude sur les tourbières tropicales du Bassin du Congo et leur contribution à la lutte contre le changement climatique*. Agence belge de développement (ENABEL), Kinshasa, RDC, 128 p.
- FAO, 2023. *The State of the World's Forests 2023*. Food and Agriculture Organization of the United Nations, Rome, Italy, 166 p.
- FONAREDD, 2023. *Rapport annuel sur le développement rural et la gestion des ressources naturelles dans le territoire de Bikoro*. Fonds National REDD+ de la République Démocratique du Congo, Kinshasa, RDC, 96 p.
- Intergovernmental Panel on Climate Change (IPCC), 2022. *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report*. Cambridge University Press, Cambridge, United Kingdom, 3675 p.
- International Union for Conservation of Nature (IUCN), 2024. *The IUCN Red List of Threatened Species*. IUCN, Gland, Switzerland, 120 p.
- Joosten H., 2015. *Peatlands, Climate Change Mitigation and Biodiversity Conservation*. Nordic Council of Ministers, Copenhagen, Denmark, 108 p.
- Joosten H. & Clarke D., 2002. *Wise Use of Mires and Peatlands: Background and Principles Including a Framework for Decision-Making*. International Mire Conservation Group & International Peat Society, Saarijärvi, Finland, 304 p.
- Kraak M.-J. & Ormeling F., 2010. *Cartography: Visualization of Geospatial Data* (3rd ed.). Pearson Education, Harlow, United Kingdom, 222 p.
- Levis C., Flores B. M., Moreira P. A., Luize B. G., Alves R. P., Franco-Moraes J., Lins J., Konings E., Peña-Claros M., Bongers F. & Costa F. R. C., 2021. How people domesticated Amazonian forests. *Frontiers in Ecology and Evolution*, 8, 584385.
- Paulus G., 2017. *Introduction aux systèmes d'information géographique*. Paris : Presses Universitaires de France, 224 p.
- Parish F., Sirin A., Charman D., Joosten H., Minayeva T., Silvius M. & Stringer L., 2008. *Assessment on Peatlands, Biodiversity and Climate Change*. Kuala Lumpur: Global Environment Centre and Wetlands International, 179 p.
- Rosset T., 2023. *Les tourbières tropicales : enjeux écologiques, climatiques et perspectives de conservation*. Paris : Éditions scientifiques, 186 p.
- Roucoux K. H., Lawson I. T., Baker T. R., Draper F. C., Del Castillo Torres D., Lähteenoja O., Gilmore M. P. & Honorio Coronado E. N., 2017. Threats to intact tropical peatlands and opportunities for their conservation. *Conservation Biology*, 31(6), 1283–1292.
- Swindles G. T., Morris P. J., Mullan D. J., Payne R. J., Roland T. P., Amesbury M. J., Lamentowicz M., Turner T. E., Gallego-Sala A., Sim T., Barr, I. D. & Blaauw M., 2019. Widespread drying of European peatlands in recent centuries. *Nature Geoscience*, 12(11), 922–928.
- Tiemoko Y., Kouamé K. & N'Guessan A., 2021. Community dependence on wetland resources in tropical Africa. *African Journal of Ecology*, 59(2), 315–327.
- United Nations Environment Programme (UNEP), 2022. *Global Peatlands Assessment: The State of the World's Peatlands*. Nairobi, Kenya: UNEP, 264 p.
- Xu J., Morris P. J., Liu J. & Holden J., 2018. PEATMAP: Refining estimates of global peatland distribution based on a meta-analysis. *Catena*, 160, 134–140.