



## **Socio-Environmental Risk Profiles Associated with Rural Activities in the Localities of the Pool Department, Republic of the Congo**

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Approved: 14 June 2026

Posted: 16 June 2026

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*Cite As:*

Makaya, H.A., & Ifo, S.A. (2026). *Socio-Environmental Risk Profiles Associated with Rural Activities in the Localities of the Pool Department, Republic of the Congo*. ESI Preprints.

<https://doi.org/10.19044/esipreprint.6.2026.p555>

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### **Abstract**

Local environmental planning requires diagnostic tools capable of identifying areas and activities that may place pressure on soils, fragile environments and water resources before these pressures become measurable deforestation or forest degradation. This study characterises socio-environmental risk profiles associated with rural activities in seven localities of the Pool Department, Republic of the Congo, using an environmental and social field database. Unlike studies centred on community perceptions or satellite time series, the analysis is deliberately restricted to environmental observations: activity types, localities, proximity to rivers or water points, reported risks to fragile environments, risks to rivers and lakes, soil instability and potential conflicts. Variables relating to sub-projects and direct beneficiaries were not used. The results show that agriculture dominates most localities, whilst Mindouli displays a mixed agro-pastoral profile, Koubola a distinctive pastoral profile, and Yalavounga, Yangui and Linzolo very high hydrological sensitivity. Reported risks to fragile environments and water resources are particularly visible in Missafou, Yalavounga and Linzolo. The paper proposes an environmental vigilance typology distinguishing multi-activity, agricultural-riparian, mixed agro-pastoral and pastoral profiles. This typology offers a practical basis for prioritising local environmental monitoring, riparian protection and the

introduction of agroecological practices in rural landscapes of the Pool Department.

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**Keywords:** Socio-environmental risks; rural activities; water resources; agriculture; livestock; Pool Department; Republic of the Congo

## Introduction

Rural landscapes in Central and West Africa are increasingly affected by agricultural expansion, livestock keeping, domestic wood use, growing accessibility and competition for land and water resources. These processes do not only result in forest loss; they also generate localised socio-environmental risks, including soil disturbance, riverbank degradation, vegetation fragmentation and pressure on riparian ecosystems. Long-term land-cover studies in West Africa have shown that human-dominated land-cover classes, particularly croplands and settlements, have expanded at the expense of natural vegetation (Vittek et al., 2014; Barnieh et al., 2020; Herrmann et al., 2020).

The Pool Department, located in southern Republic of the Congo, is particularly relevant for such an analysis. It is characterised by a forest-savannah mosaic, gallery forests, secondary forest patches, agricultural lands and hydrological networks that support rural livelihoods. Previous botanical and ecological studies in the Pool and neighbouring Congolese landscapes have shown the importance of secondary forests, degraded forests, savannahs and riparian formations for biodiversity, soil-water regulation and ecosystem functioning (Kimpouni et al., 2009; Ndzai et al., 2022; Gomat et al., 2024).

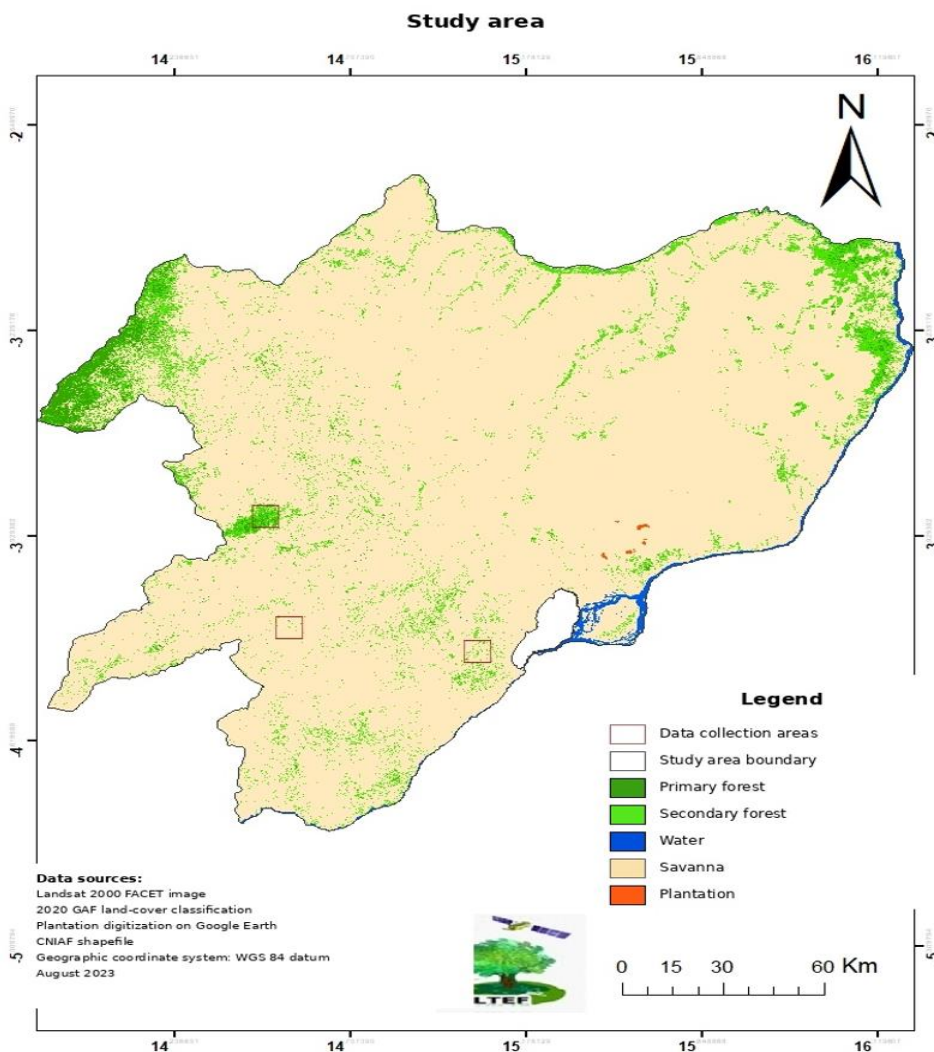
The problem addressed in this paper differs from an analysis of perceived drivers of deforestation. The central question is: how can environmental field observations be used to identify locality-level risk profiles associated with rural activities? This diagnostic perspective is important because environmental risks are not distributed uniformly across space. Evidence from West African floodplain and wetland studies shows that agricultural expansion, settlement growth and livestock pressure may affect vegetation, soils and water resources differently depending on local ecological settings (Nsor et al., 2019; Barnieh et al., 2020).

The general objective is to produce a typology of socio-environmental risks associated with rural activities in surveyed localities of the Pool Department. The specific objectives are to: (i) describe the distribution of rural activities by locality; (ii) assess hydrological proximity; (iii) compare reported risks to fragile environments and water resources; and (iv) propose environmental monitoring priorities adapted to each local profile.

## Materials and methods

### Study area

The study was conducted in localities of the Pool Department in southern Republic of the Congo: Missafou, Linzolo, Mindouli, Koubola, Yalavounga, Yangui and Nianguï. The department is a rural and peri-urban landscape where agricultural land, savannahs, gallery forests, secondary forest patches and hydrological networks interact. The physical geography of the Pool is marked by plateaux, hills and plains, with hydrographic systems that support rural livelihoods and create ecologically sensitive riparian environments (Vennetier, 1966; Monographie du departement du Pool, 2011). Figure 1 presents the general location of the study area.



**Figure 1:** General location of the study area in the Pool Department

### **Data and analytical scope**

The data were drawn from an environmental and social field database. The retained variables describe localities, activity types, proximity to rivers or water points, reported risks to fragile environments, reported risks to rivers or lakes, soil or geological instability, and potential conflicts or inequalities. Variables relating to sub-projects and direct beneficiaries were excluded in order to keep the analysis focused on environmental and territorial indicators.

This article does not use the community-perception database associated with the thesis survey. This methodological choice maintains a distinct angle: the paper examines observed risk profiles rather than perceived causes of forest decline. Results are expressed as numbers of occurrences or as percentages of completed responses. The analysis is descriptive and does not claim statistical causality.

The bibliographic framework of this article was deliberately strengthened with studies from West Africa and Central Africa that address land-cover transitions, riparian vegetation change, soil-water dynamics, savannah-forest mosaics and environmental monitoring. This choice reinforces the environmental-diagnostic orientation of the paper and distinguishes it from the companion manuscript centred on community perceptions and perceived drivers of deforestation. This comparative framing is consistent with land-cover and ecoregional assessments that document agricultural expansion, vegetation transitions and rural landscape change in West Africa (Tappan et al., 2004; CILSS, 2016; Tappan et al., 2016; Cotillon & Mathis, 2017).

### **Data processing**

Locality names were harmonised to group spelling and administrative variants. Activities were classified into five categories: agriculture, livestock, trade, fish farming and other activities. Environmental risks were compared across localities. Hydrological proximity was calculated as the proportion of completed responses indicating the presence of a river, stream or water point. The analysis led to a typology of environmental vigilance profiles based on combinations of activity structure, hydrological proximity and reported risks.

## Results

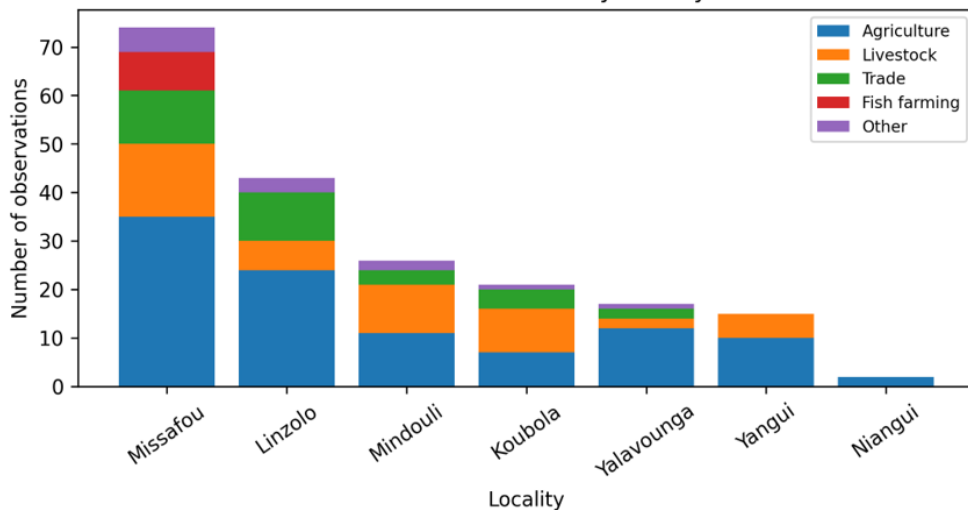
### Distribution of observed activities

**Table 1 :** Observed activity profiles by locality

Locality	Agriculture	Livestock	Trade	Fish farming	Other	Environmental profile
Missafou (Mindouli)	35	15	11	8	5	Diversified, agriculture-dominated
Linzolo (Goma tse-tse)	24	6	10	0	3	Agricultural-commercial and hydrological
Mindouli	11	10	3	0	2	Mixed farming-livestock
Koubola (Goma tse-tse)	7	9	4	0	1	Pastoral pressure on soils
Yalavounga (Kinkala)	12	2	2	0	1	Sensitive agricultural-riparian
Yangui (Kinkala)	10	5	0	0	0	Agricultural with strong hydrological proximity
Niangui (Kinkala)	2	0	0	0	0	Agricultural, limited data

Table 1 and Figure 2 show that the distribution of activities is dominated by agriculture in most localities. Missafou is the most diversified, combining agriculture, livestock, trade and fish farming. Linzolo combines agriculture and trade, whereas Mindouli shows a mixed agriculture-livestock profile. Koubola differs from the other localities because livestock is relatively dominant, which calls for a specific interpretation of risks associated with grazing routes, soil trampling and watering points.

Observed activities by locality



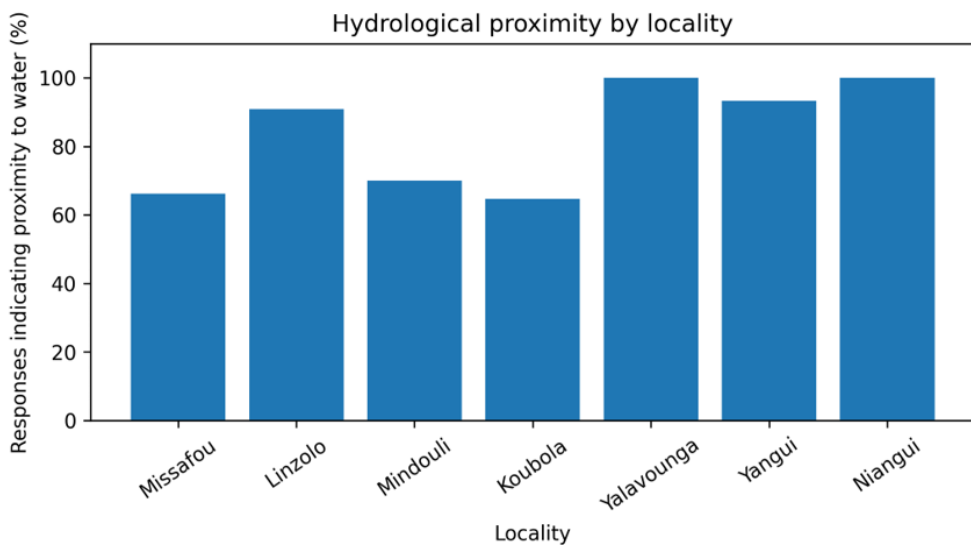
**Figure 2:** Distribution of observed activities by locality in the environmental database

## Hydrological sensitivity of localities

**Table 2 :** Hydrological proximity of environmental observations

Locality	Observations close to water	Completed responses (%)	Sensitivity level
Missafou (Mindouli)	49	66.2	Moderate to high
Linzolo (Goma tse-tse)	30	90.9	Very high
Mindouli	14	70.0	Moderate to high
Koubola (Goma tse-tse)	11	64.7	Moderate
Yalavounga (Kinkala)	17	100.0	Very high
Yangui (Kinkala)	14	93.3	Very high
Niangui (Kinkala)	2	100.0	Very high, to be interpreted cautiously

Table 2 and Figure 3 show that Yalavounga, Yangui, Niangui and Linzolo have the highest proportions of observations close to water. Niangui should be interpreted cautiously because the number of observations is low. Hydrological proximity is a central vigilance indicator because rural activities near watercourses may affect riverbanks, gallery forests, water quality and soil stability.



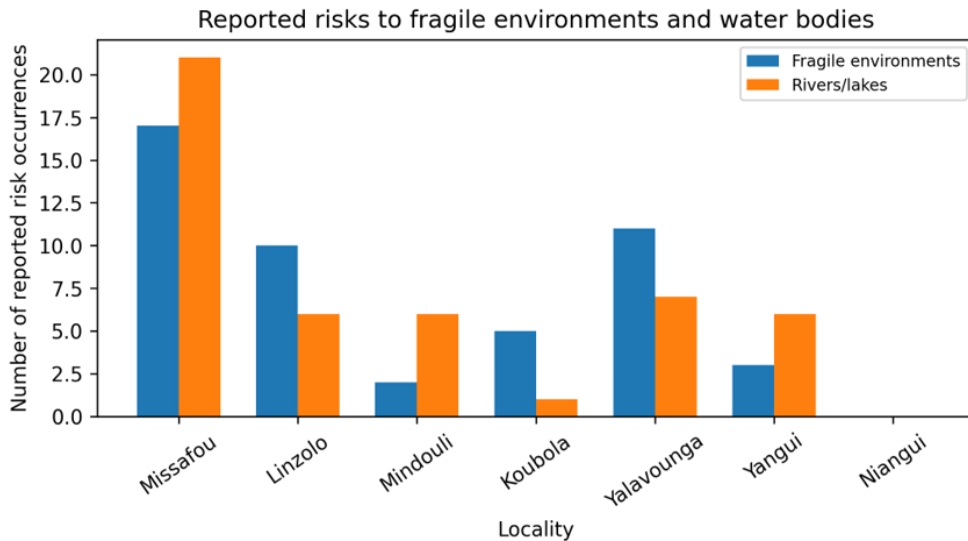
**Figure 3:** Proportion of observations indicating proximity to a river or water point

### Reported risks to fragile environments and water resources

*Table 3 : Environmental risk occurrences by locality*

Locality	Fragile environments	Rivers/lakes	Soil instability	Conflicts
Missafou (Mindouli)	17	21	0	3
Linzolo (Goma tse-tse)	10	6	1	1
Mindouli	2	6	1	1
Koubola (Goma tse-tse)	5	1	1	1
Yalavounga (Kinkala)	11	7	2	0
Yangui (Kinkala)	3	6	1	0
Niangui (Kinkala)	0	0	0	0

Table 3 and Figure 4 show that reported risks are particularly visible in Missafou, Yalavounga and Linzolo. Missafou combines the highest numbers of occurrences relating to fragile environments and rivers or lakes. Yalavounga combines very strong hydrological proximity with high risk occurrences affecting fragile environments. Linzolo also presents a sensitive profile because agriculture and trade occur in a context of strong proximity to water points.



**Figure 4:** Reported risks to fragile environments and to rivers/lakes

## Environmental vigilance typology

*Table 4 : Socio-environmental vigilance typology*

Locality	Vigilance profile	Monitoring priority
Missafou	Multi-activity hydrological-risk profile	Integrated agriculture-livestock-fish-farming planning and riparian protection
Linzolo	Agricultural-commercial hydrological profile	Control of riparian clearing and monitoring of water points
Mindouli	Mixed agro-pastoral profile	Combined management of cropping areas, grazing routes and soils
Koubola	Pastoral profile	Management of grazing routes, watering points and compacted soils
Yalavounga	Highly sensitive agricultural-riparian profile	Strict protection of riverbanks and fragile areas
Yangui	Agricultural profile with strong hydrological proximity	Vegetated buffer strips and limitation of burning
Niangui	Limited-data profile	Additional field investigation required

Table 4 identifies four main profiles: multi-activity profiles with hydrological risk, agricultural-riparian profiles, mixed agro-pastoral profiles and pastoral profiles. This typology makes it possible to prioritise monitoring measures according to local context rather than applying a uniform strategy to the entire department.

## Discussion

### Risk profiles rather than declared drivers of deforestation

The originality of this paper lies in its focus on socio-environmental risk profiles rather than on declared drivers of deforestation. This distinction is important for submission as a separate diagnostic study. While many studies in the Congo Basin focus on forest-cover loss or on the rural complex, this article uses field-based environmental variables to classify localities according to observable risk conditions. This approach is closer to applied environmental monitoring and land-use diagnosis, as recommended in long-term land-cover assessments across West Africa (Brink & Eva, 2009; Vittek et al., 2014; Herrmann et al., 2020).

The results confirm that agriculture structures most local profiles, but agriculture does not create the same risks everywhere. In Yalavounga and Yangui, agricultural observations coincide with very high hydrological sensitivity, whereas Missafou combines agricultural, livestock, commercial and fish-farming activities. This supports the conclusion that environmental diagnosis should be spatially differentiated. Similar findings have been reported in West Africa, where land-use transitions are location-specific and depend on the interaction between human activities, ecological context and water-resource conditions (Barnieh et al., 2020; Nsor et al., 2019).

## **Riparian environments as a central component of environmental diagnosis**

The high proportion of observations close to rivers or water points indicates that riparian environments should be central to environmental monitoring in the Pool Department. Studies from West African floodplains and wetlands show that agricultural encroachment, grazing, fuelwood extraction and settlement expansion can transform floodplain vegetation, reduce surface-water area, increase bare ground and intensify erosion and sedimentation (Nsor et al., 2019). In the Pool Department, recent work on degraded forest and savannah soils at Mayitoukou also highlights differences in rainwater infiltration and soil moisture dynamics between degraded forest and savannah ecosystems (Gomat et al., 2024).

The profiles of Yalavounga, Yangui and Linzolo indicate that rural activities should be accompanied by basic rules for riverbank protection: maintenance of vegetated buffer strips, limitation of riparian clearing, control of organic waste, improved management of fish ponds and prevention of trampling around water points. These measures fall under a preventive approach to degradation rather than a purely corrective response after forest loss has occurred.

## **Specificity of pastoral and agro-pastoral profiles**

Koubola and Mindouli show that socio-environmental risk cannot be reduced to agriculture alone. Livestock may generate localised impacts on soils, riverbanks and grazing areas. The Koubola profile is especially important because ecological work conducted in the secondary forest of Koubola confirms the conservation value of local secondary formations and the need to avoid further simplification of habitats (Ndzai et al., 2022). Evidence from Miombo landscapes in the Democratic Republic of Congo also shows that savannahs, degraded open forests and anthropised zones often form connected ecological units under pressure from slash-and-burn agriculture, fuelwood exploitation, bushfires and demographic pressure (Kalawu et al., 2023).

## **Implications for local environmental monitoring**

An effective environmental monitoring strategy in the Pool Department should be based on local profiles. Localities with high hydrological sensitivity require riparian buffer protection and strict control of activities close to water points. Localities with mixed agro-pastoral profiles require integrated soil, grazing and water management. Localities with diversified activities require broader land-use planning. This diagnostic approach is consistent with West African and Congo Basin studies showing that environmental change is spatially heterogeneous and that local processes

may scale up into wider landscape degradation (Brink & Eva, 2009; Barnieh et al., 2020; Gomat et al., 2024).

### **Limitations of the study**

This study does not directly measure deforestation and does not use community perceptions of its causes. It therefore does not attribute forest loss to specific actors or practices. Its contribution is more operational: it identifies where environmental vigilance should be prioritised. Future research should combine the present field-based risk typology with GPS-based spatial analysis, land-cover mapping and local ecological indicators. Such a combined approach would be consistent with African land-cover studies based on Landsat time series and with site-level ecological studies conducted in the Pool Department (Vittek et al., 2014; Herrmann et al., 2020; Gomat et al., 2024).

### **Conclusions**

This paper characterised socio-environmental risk profiles associated with rural activities in several localities of the Pool Department. By restricting the analysis to environmental field observations, it shows that localities differ in their combinations of activity structure, hydrological proximity and reported risks. Agriculture dominates most localities, but risk profiles vary substantially: multi-activity in Missafou, agricultural-riparian in Yalavounga and Yangui, agricultural-commercial in Linzolo, agro-pastoral in Mindouli and pastoral in Koubola.

The main contribution of the paper is the proposal of an environmental vigilance typology that can guide local monitoring. The results underline the need to protect riparian environments, promote agroecological practices, manage grazing routes and strengthen surveys in localities with limited data. Although the study does not quantify deforestation, it identifies local conditions likely to favour degradation of soils, riverbanks and fragile environments. It therefore provides a basis for more targeted environmental monitoring in the Pool Department.

**Acknowledgements:** The authors thank the Laboratory of Remote Sensing and Forest Ecology, Marien Ngouabi University, for scientific and institutional support during the development of this manuscript.

**Author contributions:** MAKAYA Helischa Audrey contributed to field data collection, data organisation and description of the surveyed localities. IFO Suspense Averti contributed to study conceptualisation, methodological supervision, analysis, interpretation of results and critical revision of the manuscript. Both authors read and approved the final manuscript.

**Conflict of Interest:** The authors reported no conflict of interest.

**Data Availability:** All data are included in the content of the paper.

**Funding Statement:** The authors did not obtain any funding for this research.

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