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Spatial Dynamics of Human-Primate Conflicts and Adaptive Coexistence Strategies in Togo: Contributions of Participatory Mapping and Community Perceptions

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Summary
The protected areas of Togo harbor a rich primate biodiversity that is increasingly threatened by agricultural expansion and mounting anthropogenic pressures. This study investigates the challenges of human–primate coexistence and explores pathways toward the sustainable management of natural resources, with a specific focus on crop depredation conflicts. Empirical data were collected through a combination of ethnoprimatological focus group interviews and participatory mapping exercises conducted with twenty-two (22) farming communities adjacent to five protected areas. Spatial analysis was performed using QGIS, and statistical analyses were conducted with Microsoft Excel and R software. The findings reveal that primates are perceived as major contributors to agricultural losses across all surveyed villages, with hotspots of intense crop depredation occurring in close proximity to protected area boundaries. Six recurrent landscape features were spatially delineated: watercourses, roads, human settlements, cultivated fields (particularly those subject to frequent raiding), protected areas, and buffer zones. Twelve primate species were reported by local communities, with Erythrocebus patas (23.18%) and Cercopithecus mona (19.05%) being the most frequently identified and considered the primary agents of crop damage. The severity of agricultural losses was significantly influenced by the maximum ranging distance of primates (coefficient = 0.00965, $p < 0.001$) and crop diversity (coefficient = -2.044, $p < 0.001$). A typology of three conflict-prone field categories was established: G1 = moderate losses near forest edges, G2 = high losses in immediate proximity to protected areas, and G3 = low losses at greater distances, often coupled with the implementation of various mitigation measures. Local strategies to reduce crop raiding included regular field monitoring (27.90%) and the use of scarecrows (27.20%), along with cultural and religious considerations that shape human–primate interactions. This study underscores the value of participatory mapping as a powerful tool for integrating local ecological knowledge and community perceptions into conservation planning. It offers critical insights for adaptive governance frameworks aimed at fostering peaceful and sustainable human–primate coexistence in Togo's rural landscapes.

Keywords: participatory conservation, crop depredation, human–wildlife conflict, community mapping, primates,Togo.

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1. Introduction

Since the 1990s, Togo has undergone profound landscape transformations, resulting in widespread degradation of ecosystems and natural habitats, including those within legally protected areas. Diverse native ecosystems have been increasingly supplanted by agricultural, agro-pastoral, and urban landscapes, often encroaching upon territories previously designated for biodiversity conservation (Dimobe et al., 2012 ; Martin Ferrari, 2012). During the colonial period, Togo maintained a relatively sophisticated network of protected areas that supported a rich and diverse faunal assemblage, which contributed significantly to tourism and regional ecological stability (Polo-Akpisso et al., 2016 ; Koumantiga et al., 2018 ; Polo-Akpisso et al., 2018). However, the onset of structural deforestation during the political unrest of the 1990s simultaneously precipitated the collapse of wildlife populations and destabilized local economies heavily reliant on forest resources. As documented by Tchamie (1994), this critical juncture triggered two interlinked crises across Togo's protected landscapes. The escalating degradation of protected areas across sub-Saharan Africa driven by deforestation, agricultural encroachment, and illegal hunting has led to alarming declines in primate populations. For example, populations of West African chimpanzees have declined by more than 80% over the past three decades (Tédonzong et al., 2023), while seven out of ten species of red colobus monkeys are now classified as critically endangered (Linder et al., 2024). Despite their legal protection and ecological significance, these species are experiencing sharp reductions in suitable habitat, including within designated conservation areas (Benítez-Malvido & Arroyo-Rodríguez, 2008).

As primate habitats in Togo become increasingly fragmented, conservation challenges are compounded, threatening both biodiversity and the socio-economic resilience of farming communities that coexist with these species (McAlpine et al., 2016). Habitat disturbances often compel primates to expand their home ranges into agricultural zones, leading to frequent conflict with farmers (Isabirye-Basuta & Lwanga, 2008 ; Bryson-Morrison et al., 2017 ; Mekonnen et al., 2017 ; Mekonnen et al., 2020 ; Ibrahim et al., 2023). Crop depredation events, in turn, result in significant economic losses and often provoke retaliatory responses from affected communities, posing an additional threat to primate conservation (Khatun et al., 2013).

Nonetheless, primates play a crucial ecological role as seed dispersers, thereby sustaining plant regeneration processes and overall forest ecosystem integrity (Cavada et al., 2016 ; Kaisin et al., 2021). The conservation of primates and their habitats thus aligns with broader sustainability frameworks, including several targets of the United Nations Sustainable Development Goals (SDGs), particularly those related to terrestrial biodiversity conservation. Effective mitigation of human–wildlife conflicts, such as primate crop raiding, requires a comprehensive understanding of local realities and the integration of community-based knowledge to inform adaptive biodiversity governance (Lee & Priston, 2005 ; Riley, 2007 ; Jones-Engel et al., 2011).

A holistic, interdisciplinary approach that considers ecological, socio-cultural, and spatial dimensions is essential to address these conflicts and foster sustainable human–primate coexistence (Mosandl et al., 2008 ; Nyhus, 2016 ; Luna et al., 2020 ; Alempijevic et al., 2022). Achieving such coexistence is also consistent with long-term biodiversity conservation goals (Assogbadjo & Sinsin, 2007). However, strategic and spatially explicit information to guide these policies remains critically limited in Togo (Dernat et al., 2023). In this context, participatory mapping emerges as a valuable methodological tool for documenting the spatial dynamics of human–primate interactions, identifying conflict hotspots, and supporting habitat conservation planning (Bortolamiol et al., 2013). Moreover, such participatory processes enhance inclusive decision-making and strengthen the capacity of local communities to engage meaningfully in ecosystem stewardship (Burdon et al., 2019 ; Lim et al., 2021).

In light of these interdependent ecological and socio-economic challenges, it is imperative to adopt integrated conservation strategies that support both biodiversity preservation and local resilience. This study aims to contribute to improved natural resource management and biodiversity conservation in Togo by applying participatory mapping approaches. Specifically, it seeks to deepen understanding of human–primate coexistence challenges surrounding protected areas and to identify community-based strategies for the sustainable management of natural resources.

2. Materials and methods

2.1. Study Area

This study covers five major protected areas across Togo, encompassing diverse ecological zones and climatic gradients: Fazao-Malfakassa National Park, Abdoulaye Faunal Reserve (RFA), the Togodo Complex (Togodo Nord and Togodo Sud), Alédjo Wildlife Reserve, and the Amou-Mono Classified Forest.

- ***Fazao-Malfakassa National Park***

Located in the west-central region of Togo along the Atacora mountain range, Fazao-Malfakassa National Park spans approximately 192,000 ha. It lies within the Guinean-Sudanian transition zone (ecofloristic Zone II), between latitudes 8°20′ and 9°30′ N and longitudes 0°35′ and 1°02′ E (Ern, 1979). The park features a humid tropical climate and a rich mosaic of vegetation types, including open woodland, dry forest, and gallery forests (Woegan et al., 2013 ; Kamou et al., 2017). It represents one of the most ecologically diverse protected areas in the country.

- ***Fauna Reserve of Abdoulaye (RFA)***

The Abdoulaye Faunal Reserve is situated in the Tchamba district within ecofloristic Zone III (Ern, 1979), between latitudes 8°34′ and 8°47′ N and longitudes 1°13′ and 1°25′ E. It was established by Decree No. 391-51/EF on 7 June 1951 with the goal of ensuring in-situ conservation of biodiversity, including fauna, flora, forest ecosystems, and landscapes (Adjonou et al., 2010 ; Issifou et al., 2022). The reserve serves as a critical refuge for remnant wildlife populations in central Togo.

- ***Togodo National Park (Togodo Nord and Sud)***

The Togodo protected area complex is located in southeastern Togo, between latitudes 6°40′ and 6°50′ N and longitudes 1°20′ and 1°40′ E. It consists of two distinct sites: Togodo Sud Classified Forest (15,000 ha, designated by Decree No. 534/EF on 4 July 1954) and Togodo Nord Classified Forest (80 ha, designated by Decree No. 174/EF on 26 February 1954). Situated in ecofloristic Zone III, the area experiences a sub-equatorial climate, with annual rainfall ranging from 1,000 to 1,300 mm and average monthly temperatures between 25°C and 29°C (Akodewou, 2019).

- ***Wildlife Reserve of Alédjo***

Alédjo Wildlife Reserve is located at the interface of the Tchaoudjo and Assoli districts, covering approximately 765 ha. Positioned along the Togo Mountains fault line, the reserve lies within ecofloristic Zone II, between latitudes 9°11′ and 9°17′ N and longitudes 1°00′ and 1°24′ E (Woegan et al., 2013). It falls under a semi-humid unimodal climate regime, with total annual rainfall ranging from 1,200 to 1,600 mm. Despite its relatively small size, the reserve is ecologically significant due to its location within a mountainous corridor of forest remnants.

- ***Classified Forest of Amou-Mono***

The Amou-Mono Classified Forest spans 12,780.58 ha across the districts of Ogou, Moyen-Mono, and Haho. It is situated within ecofloristic Zone III, between latitudes 7°08.4′ and 7°15.8′ N and longitudes 1°22.8′ and 1°30.0′ E (Figure 1). Initially gazetted by Decree No. 771 of 21 October 1953, the forest was reclassified in 2005 as a natural resource management zone (IUCN Category VI) under Decree No. 003/MERF/CAB of 02 February 2005. The area is characterized by a Sudano-Guinean climate with elevations generally below 400 m (Akodewou, 2019).

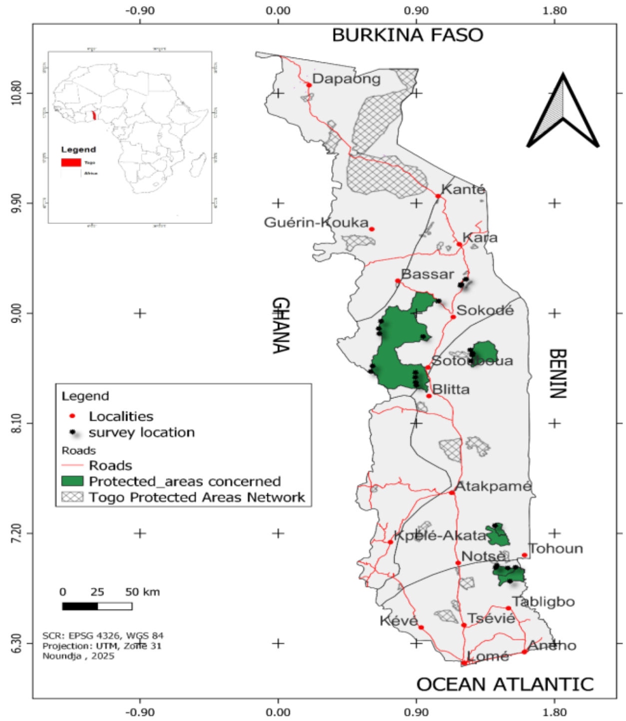

Figure 1: Maps of protected areas and surrounding communities

2.2. Data collection

A two-stage hierarchical sampling approach was employed to delineate the study area, targeting habitats favorable to primates and selecting eligible villages. This design allowed for a focused examination of zones most affected by human–primate conflicts. In the first stage, protected areas were selected based on a multicriteria analysis of ecological factors that characterize biophysical habitats suitable for primates. Key parameters included conservation status, anthropogenic pressures (Atakpama et al., 2017 ; Ahissa et al., 2022), hydrography (Kassa et al., 2007), topography, protected area size, and historical records of primate occurrence in Togo (Campbell et al., 2007 ; Campbell-Smith et al., 2010 ; Oates, 2011 ; Agbessi et al., 2017 ; Segniagbeto et al., 2017).

Each parameter was ranked on a three-point scale (1 = low, 2 = moderate, 3 = high) to assess its influence on habitat suitability. These rankings were integrated using an intersection-type spatial multicriteria analysis in ArcGIS 10.3, with the most suitable habitats receiving the highest cumulative scores (Aké et al., 2012 ; Eblin et al., 2017). This analysis identified six key protected areas: Fazao-Malfakassa National Park, Abdoulaye Faunal Reserve, the Togodo protected area complex, Amou-Mono Classified Forest, and the Alédjo Wildlife Reserve.

In the second stage, villages located within a 500-meter buffer zone of these protected areas were prioritized, as this proximity corresponds to zones most vulnerable to crop damage (Naughton-Treves, 1998 ; Naughton-Treves et al., 1998 ; Naughton-Treves, 2002 ; Zoffoun et al., 2019). From these, twenty-two (22) of the most populated villages (RGPH 4) were selected for focus group discussions and participatory mapping.

2.3. Ethnozoological Surveys

This study was authorized by the Togolese Ministry of Environment and Forest Resources (Permit No. 0402/MERF/SG/DRF, dated 29/10/2024) and conducted in accordance with ethical standards governing human–wildlife interaction studies. Following ethnobiological research principles, the methodology was adapted to the socio-cultural and ecological context through a participatory approach grounded in Free, Prior and Informed Consent (FPIC), obtained via consultation with local authorities.

Data collection involved 12 communities adjacent to Fazao-Malfakassa National Park (FMNP), with a sample of 277 participants (84.8% men), including traditional leaders, farmers, hunters, and forest rangers. An ethno-primatological framework guided the use of community-based focus group discussions to gather structured narratives on human–primate coexistence (Zoffoun et al., 2019). Each session, lasting on average 3 hours and 20 minutes, followed a semi-structured guide organized around four core themes: (1) mapping of conflict zones, (2) typology of human–primate interactions, (3) species identification using a standardized photographic guide, and (4) local mitigation strategies (Zoffoun et al., 2019).

Photographic guides featuring primate species known or suspected to occur in Togo were used to support accurate identification by participants (Alempijevic et al., 2022).

2.4. Data Processing and Analysis

Interview data were recorded using KoboCollect and exported to Microsoft Excel for processing. Quantitative analyses were conducted using Microsoft Excel and R 4.3.3, combining descriptive statistics (frequencies, cross-tabulations) and inferential statistics, including Fisher's exact test for small samples and Spearman's rank correlation for ordinal data (Abounaima et al., 2020).

Additionally, a typological classification of the surveyed localities was conducted using cluster analysis to categorize villages based on conflict profiles, considering variables such as damage intensity, species involved, estimated maximum travel distance of primates, and mitigation measures used.

2.5. Participatory Mapping

A preparatory phase included standardized training for local participants in cartographic principles, including: (1) interpretation of high-resolution orthophotos (Google Earth 2023; 1050 × 624 pixels; scale 1:40,000), (2) semiological standardization of spatial symbols, and (3) protocols for transferring spatial information to physical maps (Kankeu & Tiani, 2014).

Community mappers, selected from focus group participants under village authority supervision, conducted the mapping using a georeferenced participatory methodology (Kankeu & Tiani, 2014). Spatial features were categorized into three types: Point features (e.g., dwellings, social infrastructure), Polygon features (e.g., fields, forest patches, protected area boundaries), Linear features (e.g., roads, rivers). While linear features exhibited high mapping consistency due to their clear aerial signatures, the mapping of protected area boundaries revealed notable discrepancies, highlighting divergences between local spatial knowledge and formal cartographic representations. Analog maps were digitized (CamScanner 6.88, 600 dpi), then vectorized in QGIS 3.22 via a process involving: (a) georeferencing in the national coordinate system, (b) precise digitization of spatial entities with topological control, and (c) integration into a relational geospatial database.

Each layer was cross-validated through triangulation between community knowledge, differential GPS data, and satellite imagery (Chapin et al., 2005 ; Palsky, 2010 ; Kankeu & Tiani, 2014).

2.6. Field Prospecting

To validate spatial data, community mappers accompanied researchers to conflict zones identified during mapping. During these ground-truthing surveys, GPS coordinates (±3 m accuracy) were systematically recorded to georeference crop damage locations and assess patterns of primate incursions. This phase served two main purposes: (1) empirical verification of the positional accuracy of community maps, and (2) enrichment of spatial data with local ecological insights (Marchal & Hill, 2009). The integration of indigenous knowledge and systematic spatial data collection facilitated a robust, multi-method analysis of the human–primate interface, essential for developing evidence-based mitigation strategies.

3. Results

3.1. Participatory Mapping Across Different Reserves

The analysis of participatory maps revealed six recurring spatial entities structuring land-use configurations and competing territorial claims: watercourses, roads, human settlements, cultivated fields (particularly those prone to crop-raiding), protected areas, and buffer zones. These maps highlighted local-specific details based on communities' intimate knowledge of the territory, especially regarding access points to protected areas.

- *The Fazao-Malfakassa National Park, the participatory maps*

In the case of the Fazao-Malfakassa National Park, the participatory maps illustrated the current legal boundaries of the park in relation to nearby human settlements. Agricultural plots were found to extend up to the regulatory limits of the protected area, with clearly delineated crop depredation zones adjacent to these boundaries. These damage-prone zones varied in size but were consistently located at the interface between cultivated areas and the park. Areas with lower frequency of primate incursions extended outward from village peripheries, often forming crescent-shaped buffer zones.

The maps also detailed the location of major human settlements, roads, rivers (e.g., Mangu N'Boo, Kpéyi), community forests, public plantations, as well as socio-cultural landmarks such as the Hezoudè community center, village chief palaces, cemeteries, and places of worship. These representations provided crucial insights into community spatial cognition, territorial use patterns, and the physical overlap between human activities and wildlife habitats.

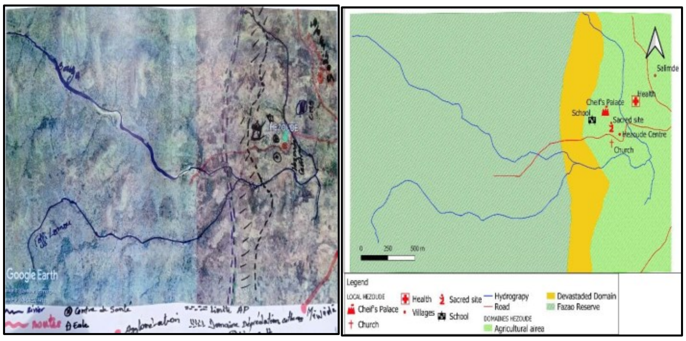

Figure 2: Participatory map of areas of depredation of agricultural crops around the FazaoMalfacassa National Park

- *Map of Abdoulaye Reserve*

The participatory maps produced by communities surrounding the Abdoulaye Reserve primarily depicted agricultural zones, the protected area, and crop-raiding zones associated with primate incursions. Key landscape features such as rivers, roads, and settlements were clearly represented, along with spatial distinctions between community forests, privately owned forest patches, and transitional corridors.

The Mono River delineates the official boundary of the reserve, beyond which lie cultivated fields. Fields frequently affected by crop damage are typically located at a distance from residential areas, predominantly along the western bank of the Mono River and in the vicinity of private forest habitats. Crop depredations in this area occur mainly prior to the onset of sustained river flooding, corresponding with periods of market gardening, tuber cultivation, or delayed harvests.

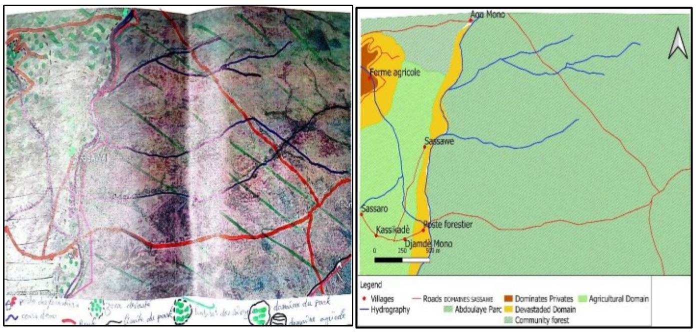

Figure 3: Participatory maps of crop depredation zones around the Abdoulaye Reserve

- *Maps of Togodo protected areas complex*

A distinctive feature of the participatory maps produced by communities around the Togodo complex is the detailed representation of human–primate interactions and the hierarchical distribution of habitats among different primate species. From the outer edge to the interior of the reserve, a succession of habitats is observed: patas monkeys, then mona monkeys, followed by an overlap of colobus monkeys and red-bellied monkeys further inside the reserve. The maps also indicate the Planned Agricultural Development Zones (ZAAP) in the southwest, with the ZAAP directly bordering the reserve experiencing significant crop depredation. Fewer details are provided on human infrastructure, except for roads and rural tracks.

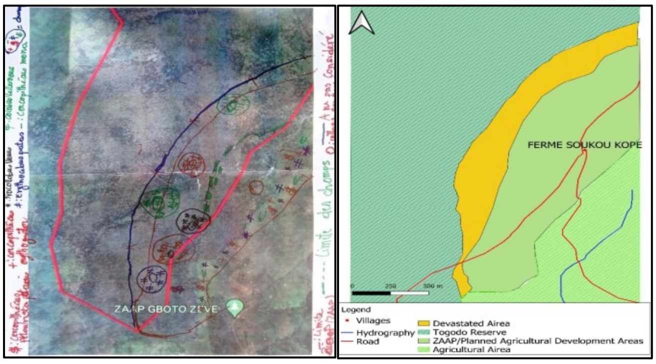

Figure 4: Participatory maps of crop depredation zones around the Togodo Reserve

- *Maps of Alédjo*

All maps of Alédjo delineate the full boundaries of the reserve. They provide more cartographic details, such as the location of telecommunication towers, municipalized plots, the chief's house, the Alédjo Fault, as well as muskets and Fulani camps. Only the protected reserve was recognized as the natural habitat of primates, while crop depredation was concentrated in agricultural zones directly adjacent to the reserve.

- *Maps of Amou-Mono*

The maps produced by communities bordering the Amou-Mono reserve clearly indicate the recognized legal boundaries of the protected area and other geographical entities in the immediate environment. These include rural tracks, watercourses, agricultural zones, and areas subject to crop damage by primates, which form a buffer zone around the reserve. The maps identify the range of primates known in the region, notably Erythrocebus patas.

3.2. Perceptions of Primate Diversity

Twelve (12) primate species were reported by local communities, with Erythrocebus patas being the most frequently recognized (23.18%), followed by Cercopithecus mona (19.05%), and Papio anubis and Galago senegalensis (14% each). In contrast, the least reported species included Pan troglodytes verus (1.12%), Galagoides demidovii, and Perodicticus potto juju (each $<1\%$). Statistical analysis revealed significant differences in species recognition among communities ($r^2 = 0.80$; $p < 0.001$). Spatial ubiquity analysis showed that Erythrocebus patas was reported in 100% of the protected areas surveyed, followed by Papio anubis and Chlorocebus aethiops (each in 80%, or 4 out of 5 sites). Less frequently identified species included Pan troglodytes verus and Procolobus verus, both reported only near Fazao-Malfakassa and Togodo, while Galagoides demidovii and Perodicticus potto juju were exclusively associated with the Fazao-Malfakassa National Park (1 out of 5 sites) (Table 1). The chimpanzee (Pan troglodytes verus) and the Juju (Perodicticus potto juju) are well known to the population but with no confirmed recent sightings and are probably locally extinct. Seven of the twelve identified species were reported to engage in crop depredation in the areas surrounding their habitats. The two primary culprits were Erythrocebus patas (55.14%) and Cercopithecus mona (32.07%) of all mentions (Table 1). ANOVA results indicated a significant association between the type of crops being damaged and the protected area concerned ($F = 47.04$, $p < 0.001$).

Table 1. Specific richness of primates according to the protected areas studied.

Species	Fauna Reserve of Abdoulaye	Wildlife Reserve of Alédjo	Classified Forest of Amou-Mono	Fazao Malfakassa National Park	Togodo National Park	Relative frequency reported (%)
Erythrocebus patas	***	**	**	***	**	23,18
Cercopithecus mona	**	NC	NC	**	**	19,05
Galago senegalensis	**	NC	NC	**	0	14,83
Papio anubis	**	NC	NC	**	*	14,11
Cercopithecus erythrogaster	NC	NC	0	0	**	11,33
Colobus vellerosus	0	NC	NC	**	**	4,37
Cercopithecus petaurista petauris	NC	NC	0	*	0	4,22
Procolobus verus	NC	NC	NC	**	0	3,70
Chlorocebus aethiops	***	***	0	***	*	2,87
Pan troglodytes verus	NC	NC	NC	0	0	1,12
Galagoides demidovii	NC	NC	NC	**	NC	0,71
Perodicticus potto juju	NC	NC	NC	0	NC	0,50

*Legend: NC unrecognized or unidentified; 0 extinct; * rare and unlikely; ** low abundant; *** abundant species. It is important to note the difference between unidentified and switched off. Unidentified species are species that have never been seen before, whereas extinct species are those that existed in the past but are no longer present.*

3.3. Factors Influencing the Intensity of Agricultural Losses

Correlation analysis revealed that the maximum ranging distance of primates is positively and significantly correlated with the intensity or amount of annual reported agricultural losses ($r^2 = 0.53$, $p < 0.001$). The amount of crop loss is also associated with the diversity of predator species ($r^2 = 0.23$, $p = 0.006$). However, there is no significant correlation between the maximum ranging distances estimated by communities and those actually measured ($r^2 = 0.05$, $p = 0.543$). The mean distances were 647.8 m (estimated) and 443.2 m (measured), suggesting a local overestimation.

Two distinct prevalence zones were identified: a high-prevalence zone (300 m) and a low-prevalence zone (2,000 m) in Mewedè, Hezoudè, Matchatom, and Kpetchila. The shortest distances (50 m) were reported in the western part of the Abdoulaye Wildlife Reserve.

Multiple regression analysis of ecological variables related to human-primate conflicts around Togo's protected areas indicated that maximum ranging distance (coefficient = 0.00965, $p < 0.001$) and crop diversity (coefficient = -2.044, $p < 0.001$) significantly influence the intensity or quantity of agricultural losses. The multiple regression model proved to be stable

Tableau 2: Results of multiple regression of variables influencing agricultural losses

Variable	Estimate	Std. Error	T-value	P-value	Signif.
Estimated_distance	0.00965	0.00140	6.90	2e-10	***
Assessed_distance	-0.00044	0.00316	-0.138	0.890	
Predator_species	0.743	0.541	1.373	0.172	
Ptotected_area	-0.030	0.833	-0.036	0.971	
Crop_devastated	-2.044	0.727	-2.812	0.0057	**
Control_measure	1.174	0.850	1.381	0.170	

*Legend: Significance rate for variables influencing farm losses ** average; *** very high significance rat*

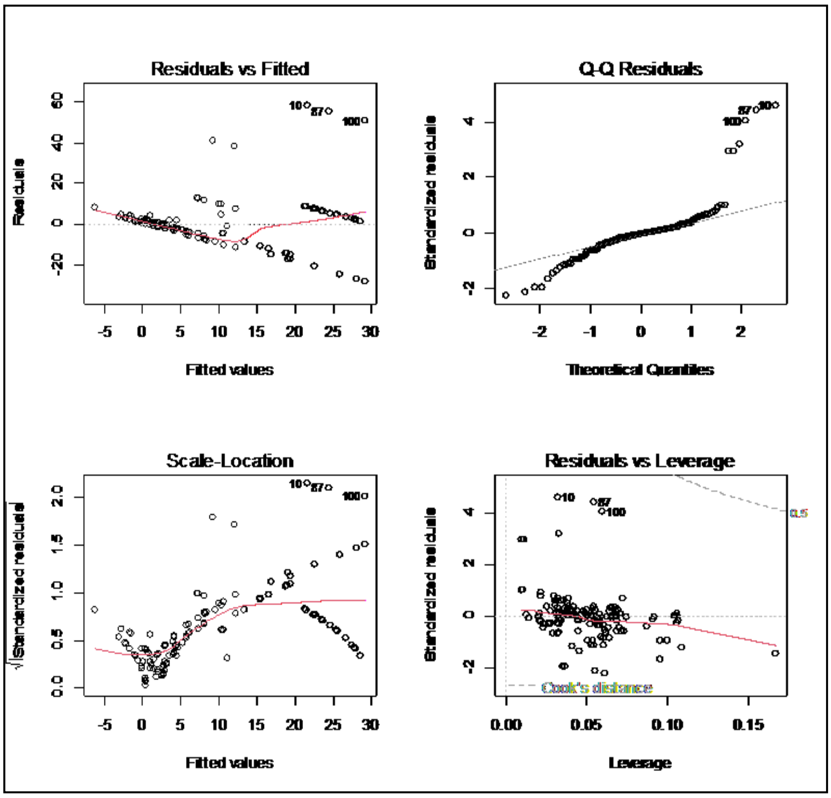

Figure 5: statistical model for diagnosing multiple regression of human-primate conflicts linked to depredation

3.4. Typology of Conflict Profiles and Management Implications

The typological analysis of communities adjacent to protected areas revealed three distinct groups based on differing conflict profiles (G1, G2, and G3). Group 1 (G1) includes communities with moderate crop losses and located relatively close to protected areas. Group 2 (G2) consists of communities situated very close to protected areas, experiencing high levels of crop loss and implementing few control measures. Group 3 (G3) comprises more distant communities with relatively low crop losses and a wide range of control strategies. ANOVA testing confirmed that the groups differ significantly in terms of the intensity of annual agricultural losses ($F = 12.3$, $p < 0.001$).

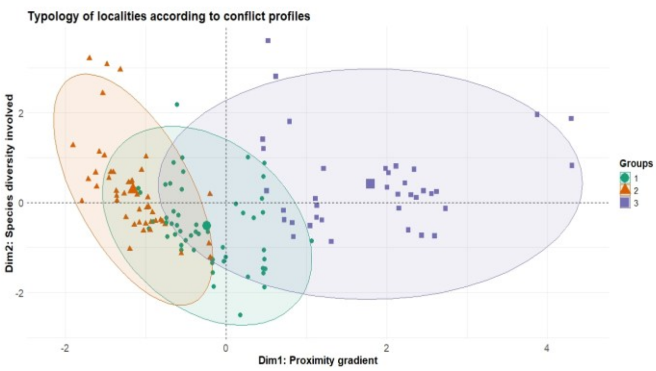

Figure 7: typology of riparian fields according to human-primate conflict profiles on crop depredation

- *Local Strategies for Coexistence with Primates*

Six local strategies or depredation mitigation measures are employed to manage conflicts and reduce the intensity of damage caused by primates. The most commonly used strategies are regular monitoring (27.90%) and the deployment of scarecrows (27.20%). Following these, the adoption of less palatable crops and regular hunting are moderately applied, accounting for 16.17% and 13.10% respectively. Lastly, the least frequently implemented measures include the production of sounds and noise (9.40%) and the use of fire and smoke (6.23%).

Regarding perceived effectiveness, the most efficacious measures reported are regular monitoring (41.72%), installation of scarecrows (27.54%), crop substitution with less preferred species (17.59%), and the generation of auditory deterrents (13.14%). The effectiveness of these measures varies significantly across localities ($r^2 = 0.8$, $p < 0.001$).

In addition to these technical approaches, biodiversity management practices that respect primate habitats and species are observed. Notably, cultural and religious practices including religious prohibitions, taboos, totems, and the conservation of community forests that serve as primate habitats play a crucial role.

Cultural and religious perceptions of primate species vary considerably among ethnocultural groups ($r^2 = -0.73$, $p < 0.05$). Totemic species reported include Colobus vellerosus and Cercopithecus erythrogaster, recognized respectively by 91% and 67% of the Ewe and Adja communities around the Togodo complex. Other species such as Chlorocebus tantalus, Erythrocebus patas, and Papio anubis, though less frequently mentioned, hold cultural and totemic significance for certain Kotokoli, Bassar, and Kabyè communities residing near the Fazao Malfacassa and Alédjo reserves. Among the Muslim communities (Kotokoli, Bassar, and Peuhl) encountered, the consumption of monkeys is explicitly prohibited.

4. Discussion

Participatory mapping of natural habitats and primate crop depredation zones around protected areas in Togo reveals six main types of spatial units: rivers, roads, agricultural lands, protected areas, and frequently degraded agricultural zones. Variations in specific map details may be attributed to local particularities related to natural features or the communities' intimate knowledge and access to the protected areas. The detailed maps of Togodo, which illustrate a hierarchical arrangement of primate-specific habitats, likely reflect the differential adaptability of primates to human influence and the local communities' profound understanding of their environment. Participatory mapping thus serves as an effective tool to assess local knowledge and their potential for sustainable and integrated management of wildlife resources and habitats (Nonjon & Liagre, 2012 ; Diop et al., 2022). Tsakem et al. (2015) recommend participatory mapping as a strategic means for resolving human-wildlife coexistence conflicts. A key outcome of this approach is highlighting the recognition of regulatory boundaries of protected areas, which may help to reconcile critical discrepancies between local perceptions of protected area limits and official cartographic representations. By capturing indigenous spatial knowledge, participatory mapping is recognized as a strategic method for resolving human-wildlife conflicts.

The delineation of crop depredation zones fits within this framework of managing coexistence between primates and local farmers. The maximum foraging distance varies considerably and is defined based on the frequency of occurrence and severity of damage. The discrepancy between the estimated mean maximum foraging distance (647.8 m) and the observed one (443.2 m) may reflect overestimations (Mackenzie & Ahabyona, 2012). Results indicate that zones of intense crop depredation are located in close proximity to protected area boundaries

while the maximum foraging distance positively correlates with cumulative agricultural losses. This apparent contradiction is explained by distinguishing between damage intensity and cumulative damage quantity. Variability in maximum incursion distances delineating high- and low-occurrence zones is likely influenced by human presence around settlements (Hickey et al., 2013 ; Kambire et al., 2021). Additionally, this variability may indicate the determined behavior of predators to reach specific, more lucrative resources. This finding aligns with hypotheses concerning the sensitivity of certain depredating species, such as chimpanzees and bonobos, whose movements are influenced by fruit availability and human presence (Blanco & Waltert, 2013).

The three distinct categories of fields help elucidate the influence of distance and human presence. Fields closest to primate habitats, with minimal control measures, suffer the greatest losses, whereas more distant fields, equipped with a wider array of mitigation strategies, experience relatively lower losses despite higher diversity of crop raiders. This zoning underscores the necessity to understand and map the maximum foraging distances of primates to design effective crop depredation management strategies (Zoffoun et al., 2019).

Analysis of conflict patterns suggests that increased crop diversity (coefficient = -2.044) may reduce the intensity of agricultural losses, whereas monocultures present more attractive and accessible targets for primates. These results corroborate findings by Estrada et al. (2017) ; Korchia (2020), which link crop raiding behavior to food availability and species preference for disturbed areas. Given these specificities, it is recommended that control and mitigation measures be tailored to conflict zone typologies (Dickman et al., 2013). Establishing buffer zones around protected areas may be most appropriate in high-prevalence zones (Perelló et al., 2012). Typologies of buffer zones involving the planting of thorny barriers such as Caesalpinia bonduc (Zoffoun et al., 2019), tea, or chili fields (Bortolamiol et al., 2013 ; Chapman et al., 2018) may also prove locally effective. These buffer measures would be particularly relevant for Fazao-Malfakassa National Park and the Togodo complex, which exhibit the greatest maximum foraging distances. For Abdoulaye Reserve, where crop raiding primarily occurs during off-season vegetable cultivation, chili fields could offer substantial mitigation potential.

Understanding local knowledge was fundamental to diagnosing the problem of depredation and identifying the primate species most detrimental to farmers (Gadgil et al., 1993 ; Dentzau, 2019). As Karimullah et al. (2022) emphasize, enhanced understanding of human-wildlife interactions especially involving primates can promote positive behavioral change and inform effective conflict mitigation strategies. Such strategies are more successful when integrated with local socio-ecological contexts (Hockings & McLennan, 2012 ; Bryson-Morrison et al., 2017 ; Estrada et al., 2017 ; Mekonnen et al., 2020). Hence, participatory maps of crop depredation zones around protected areas in Togo provide critical insights into the dynamics between primates and farming communities, laying a foundation for sustainable coexistence strategies. This integrated approach acknowledges shared responsibility between humans and wildlife, as conflicts generally arise either from human encroachment into natural habitats or wildlife intrusion into human-dominated areas (White & Ward, 2010 ; Young et al., 2020).

5.Conclusion

Participatory mapping of primate habitats in Togo represents an innovative and collaborative approach for promoting the sustainable management of natural resources and harmonious coexistence between local populations and wildlife. Farmer's perceptions of living near protected areas and their experiences with primates are strongly influenced by the extent of the damage caused by crop depredation that they endure. By employing participatory mapping of primate habitat, this study has clarified areas of conflict between primates and local farming populations, delineating areas of high crop damage closest to the boundaries of protected areas. This approach offers promising prospects for balanced ecosystem management and conflict management, encouraging more peaceful human-wildlife interactions in Togo Nevertheless, future research is needed to deepen our understanding of human-primate interactions and explore viable solutions to strengthen the commitment of local communities to conservation. Further studies should also evaluate the socio-economic implications of crop depredation and consider other wildlife species to support an integrated and holistic natural resource management.

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