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Assessment of Biodiversity and Socioeconomic Factors in Areas Affected by Fires in the Miombo Forest, Alto Catumbela Sector

Avaliação da Biodiversidade e Factores Socioeconómicos em Áreas Afectadas pelas Queimadas na Floresta de Miombo, Sector do Alto Catumbela

Evaluación de la Biodiversidad y Factores Socioeconómicos en Áreas Afectadas por Incendios en el Bosque de Miombo, Sector del Alto Catumbela

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Abstract:
The disturbances of terrestrial ecosystems result from increasing anthropogenic pressure, making the integrated assessment of biodiversity and associated socio-economic factors imperative. The present study was developed in two methodological stages in the Alto Catumbela Sector. In the first stage, a structured survey was applied to 145 residents, of which 95 responses were validated for analysis, corresponding to a margin of error of less than ± 10%. The data collected were analyzed by descriptive statistics based on absolute and relative frequencies. The results revealed that 60% of the respondents reported regular occurrence of fires, and 82.11% identified the intentional anthropogenic ignition as the main cause of the fires. In addition, 62% reported that they resorted to fire to carry out hunting and cleaning activities of agricultural fields, 52.63% recognized direct negative impacts on local faunal diversity and 95% showed no training in environmental education. In the second stage, the floristic and faunal biodiversity was characterized by calculating the Shannon-Wiener (H') indexes, Pielou equitability (J'), Menhinick, Margalef and Simpson (D). The analysis of the ten sampling plots showed that plot 8 recorded the highest values of diversity for flora and fauna. The faunal community presented a greater range of variation of the H' index (0.610–1.929) compared to the floristic community (0.660–1,359), indicating superior variability in the alpha diversity of the fauna. Based on the results of ecological indices and community perception, a proposal for ecological restoration was designed according to the principles of the Society for Ecological Restoration, sustainable management of the use of fire.
Keywords: Conservation; vegetation diversity; Miombo; ecological restoration.

Resumo:
As perturbações dos ecossistemas terrestres resultam da pressão antrópica crescente, tornando imperativa a avaliação integrada da biodiversidade e dos factores socioeconómicos associados. O presente estudo foi desenvolvido em duas etapas metodológicas no Sector do Alto Catumbela. Na primeira etapa, aplicou-se um inquérito estruturado a 145 moradores, dos quais 95 respostas foram validadas para análise, correspondendo a uma margem de erro inferior a ± 10%. Os dados recolhidos foram analisados por estatística descritiva com base em frequências absolutas e relativas. Os resultados revelaram que 60% dos inquiridos reportaram ocorrência regular de incêndios, sendo que 82,11% identificaram a ignição antrópica intencional como a principal causa das queimadas. Adicionalmente, 62% declararam, que

recorrem ao fogo para realizar actividades de caça e limpeza de campos agrícolas, 52,63% reconheceram impactos negativos directos sobre a diversidade faunística local e 95% evidenciaram ausência de formação em educação ambiental. Na segunda etapa, caracterizou-se a biodiversidade florística e faunística mediante o cálculo dos índices de Shannon-Wiener (H'), equitabilidade de Pielou (J'), Menhinick, Margalef e Simpson (D). A análise das dez parcelas de amostragem demonstrou que a parcela 8 registou os valores mais elevados de diversidade para flora e fauna. A comunidade faunística apresentou maior amplitude de variação do índice H' (0,610–1,929) comparativamente à comunidade florística (0,660–1,359), indicando variabilidade superior na diversidade alfa da fauna. Com base nos resultados dos índices ecológicos e a percepção comunitária, desenhou-se uma proposta de restauração ecológica segundo os princípios da Society for Ecological Restoration, gestão sustentável do uso de fogo.
Palavras-chave: Conservação; diversidade da vegetação; Miombo; restauração ecológica.

Resumen:
Las perturbaciones de los ecosistemas terrestres son el resultado del aumento de la presión antropogénica, lo que hace que la evaluación integrada de la biodiversidad y los factores socioeconómicos asociados sean imprescindibles. El presente estudio se desarrolló en dos etapas metodológicas en el Sector del Alto Catumbela. En la primera etapa, se aplicó una encuesta estructurada a 145 residentes, de los cuales 95 respuestas fueron validadas para el análisis, correspondiente a un margen de error de menos de ± 10%. Los datos recogidos fueron analizados mediante estadísticas descriptivas basadas en frecuencias absolutas y relativas. Los resultados revelaron que el 60% de los encuestados reportaron la ocurrencia regular de incendios, y el 82,11% identificó la ignición antropogénica intencional como la principal causa de los incendios. Además, el 62% informó que recurrió al fuego para realizar actividades de caza y limpieza de campos agrícolas, el 52,63% reconoció impactos negativos directos en la diversidad de la fauna local y el 95% no mostró formación en educación ambiental. En la segunda etapa, la biodiversidad florística y faunística se caracterizó por el cálculo de los índices Shannon-Wiener (H'), la equitabilidad Pielou (J'), Menhinick, Margalef y Simpson (D). El análisis de las diez parcelas de muestreo mostró que la parcela 8 registró los valores más altos de diversidad para la flora y fauna. La comunidad faunística presentó un mayor rango de variación del índice H' (0.610–1.929) en comparación con la comunidad florística (0.660–1.359), lo que indica una variabilidad superior en la diversidad alfa de la fauna. A partir de los resultados de los índices ecológicos y la percepción de la comunidad, se diseñó una propuesta de restauración ecológica de acuerdo con los principios de la Sociedad para la Restauración Ecológica, manejo sostenible del uso del fuego.
Palabras clave: Conservación; diversidad de vegetación; Miombo; restauración ecológica.

Introduction

The forests of Angola are characterized by a great diversity of species, distributed in different strata of vegetation, housing numerous forms of life that play an important role in the maintenance of ecosystems; in addition, it is a fundamental resource to meet the needs of rural populations (Dalu et al., 2021)

Biodiversity has been declining, resulting from anthropogenic activities that contribute to habitat loss, flora and fauna degradation, and that if not reversed will reduce the benefits available and necessary for the livelihoods of the people to come (FAO, 2020).

Babaera, like many other municipalities in the country, faces challenges arising from human activities, among them: uncontrolled fires, illegal cutting of timber, cutting and burning agriculture; these practices can on the one hand cause environmental degradation from greenhouse gas emissions, exacerbating adverse weather conditions, and on the other hand can compromise biodiversity, and the availability of resources for future generations. Implementation of the present study contributes not only to the evaluation and understanding of the state of biodiversity, but also provides support to information on the socio-economic impacts in the Alto Catumbela Sector.

Theoretical Framework

Angolan Forest Heritage

Angola represents the global height of biological diversity, and can be recognized four distinct types of forests: firstly the closed forests, more extensive and rich in species, are those with guineo-Congolese floristic affinity; secondly, extremely limited areas of Afro-mountane forests that occur in the highest mountains; a third type of forest, comprising elements of the Guineo-Congolese and Zambezian flora, occurs along the slopesperennial forests of *Cryptosepalum* of Moxico, have a closed canopy and many characteristics of forest, physically attending various forest criteria, but, floristically, are part of the biome of savanna Méssica (Burgess et al., 2021).

Structure, Composition and Ecology of the Miombo Forest

Miombo is one of the largest tropical savanna ecosystems in Southern Africa, extending for about 2.7 million km2 and covering countries such as Angola, Zambia, Tanzania, Malawi, Zimbabwe and Mozambique (Ryan, 2016). Miombo plays a crucial role in the conservation of biodiversity, in the regulation of climate and hydrological cycles, as well as in the livelihood of millions of people who depend on their resources for food, energy, health and income (Lowe et al., 2000).

In Angola this biome mainly covers the highlands of the Provinces of Huambo, Benguela, Bié, Malanje, extending to the regions of Lundas, Moxico, Cuando and Cubango; it is characterized mainly by the species of the genera *Brachystégia, Julbernardia* and *Isoberlinia*, belonging to the family Fabaceae, adapted to tropical and subtropical climates, the predominant vegetation is mostly deciduous, marked seasonality (Olsson, et al., 2019)

Materials and Methods

This section systematically describes the methodological design used to assess biodiversity and socio-economic factors in areas affected by fires in the Alto Catumbela Sector. The sector is located in the municipality of Babaera, Benguela Province, between the geographical coordinates 12.8997553° S and 14,8016887° E, with a territorial extension of 81.2 km2. The predominant climate is wet mesothermic, with moderately rainy water regime, average annual temperature between 22 °C and 35 °C, and average rainfall of 1 200 mm (Babaera Municipal Administration, 2024). The vegetation corresponds to a mosaic of miombo forests (*Brachystégia* and *Julbernardia*), shrub savannas, *Eucalyptus sp.* plantations, seasonal swamps and dry pastures, representative of the wet savanna biome of the Zambeze (Burgess et al., 2021; Huntley, 2023).

The selection of the area was based on the high incidence of fires documented by Global Forest Watch (2024), for the Province of Benguela, particularly between the months of June and October, with a peak between the months of August and September. The wavy topography and the presence of oriented escarpments from east to west generate microclimates that modulate the distribution of vegetation and the intensity of fire, setting up an ideal disturbance gradient for biodiversity studies and ecological restoration (Ribeiro et al., 2022; Falcão et al., 2024).



Figure 1- Geographical location of the Catumbela Act sector. Source: adapted from INE (2025)

Diagnosis of Socio-economic Impacts

A mixed, sequential and complementary research design was adopted, with the integration of quantitative methods for the socio-economic component, and descriptive-observational methods for the ecological component. This design allowed to evaluate the community perception with the ecological indicators studied in the field; likewise allowed the triangulation of data and the internal validity of the study (Creswell & Creswell, 2018; Falcão et al., 2024).

Survey of Questionnaire Addressed to the Local Population

The exploratory survey was the first stage of this field research, to achieve the related information about perceptions, direct experiences with fires and their environmental, social and economic consequences in the Alto Catumbela Sector and help to understand the possible changes in biodiversity from the point of view of the surrounding population.

A simple random sampling was used; the instrument consisted of a structured questionnaire with seven closed questions and an open question, written in Portuguese and umbund language to ensure cultural and linguistic understanding. The dimensions of the questionnaire covered: (i) occurrence and frequency of fires; (ii) causes attributed (human vs. natural); (iii) motivations for the use of fire (agriculture, hunting, pasture renewal); (iv) perception of

impacts on fauna and agricultural productivity; and (v) level of knowledge in environmental education (FAO, 2021; Cunha, 2022).

Population and Sample Size

The target population was made up of the adult inhabitants of the Alto Catumbela Sector. The total universe corresponded to N = 1 532 individuals, estimated from local administrative records. The sample size was determined by consultation of the Glenn table (1992), an instrument that establishes minimum sample sizes according to the population universe and the tolerated margin of error (see Appendix 1). A confidence level of 95% and a margin of error of ± 10% were adopted, the target group was mainly individuals aged between 20 and 75 years, both male and female, since according to the nature of study and field experiences.

Delimitation of Parcels for Ecological Study

Within the Alto Catumbela sector, an area of 10 hectares previously georeferenced was delimited, 10 sampling plots of 20 m × 20 m (400 m2 each) were installed, randomly distributed, following the protocols of (Andrew, 2023 & FAO, 2013) for inventories in mineombo forests, and biodiversity studies. The size of the plots selected was due to the fact that it allows to capture the structural variation of wood species without compromising the operational viability of the field work (Ribeiro et al., 2022).

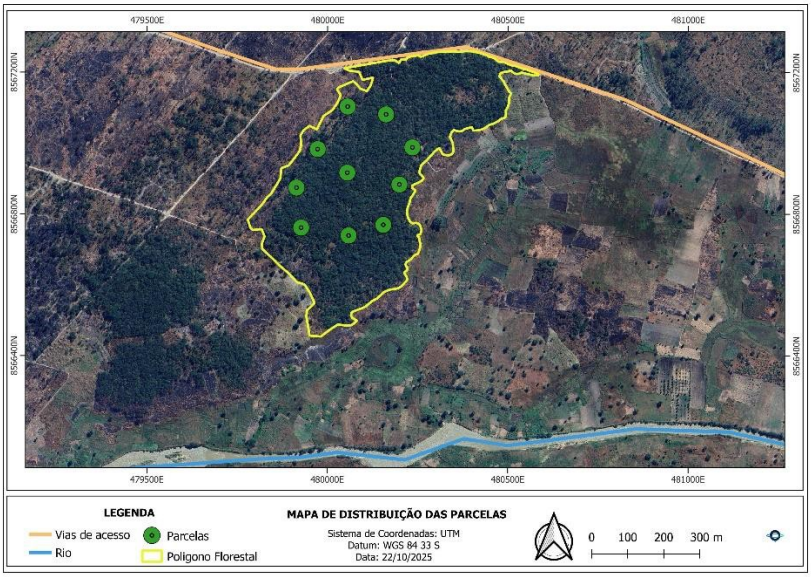

Figure 2- Distribution of sample plots in the study area. Adapted source of Google hearth (2025)

Determination of the Diversity of Flora and Fauna

In each plot were counted all woody individuals with registration: (a) local name (in umbund and Portuguese); (b) scientific name; (c) vertical stratum (arboreal, shrub). The taxonomic identification was carried out in situ with identification of the flora species through the aid of the manual of thirty species of Angolan miombo by the author Sanfilippo.
The insects were identified by families or gender, using taxonomic keys made available by the Entomology laboratory of the Faculty of Agricultural Sciences of Huambo. The indirect traces of vertebrate fauna such as animal waste and hiding places were recorded through digital photography and field notes.

Determination of the Sampling Sufficiency of Biodiversity

To evaluate whether the effort of the sample was representative, species accumulation curves (collector curves) were constructed using the abundance data per plot. This analysis was made using the BioDiversity Pro 2.0 software, although the descriptive calculations remained in Excel to ensure reproducibility.

Statistical Processing of Biodiversity Data and Ecological Indices

The evaluation of biodiversity was performed through descriptive statistical analysis, in which the biological diversity indices were determined, to identify the relevant factors associated with changes in biodiversity in the studied area. After collecting the data, they were organized and processed in the Excel application. The sampling sufficiency was evaluated through species accumulation curves or collector curve (Gotelli et al., 2001), constructed with species abundance data observed in the 10 sampling plots.

Results and Discussion

Perception of the Community About the Occurrence of Fires, Their Causes and Use in Agricultural and Hunting Activities

According to the data obtained, 60% of the surveyed population confirmed the regular occurrence of fires in the Alto Catumbela Sector (Figure 3A). The interpretation of these data is contextualized within the climatic reality of Angolan miombo, in which the months of June to October constitute the period of highest incidence of fires, with a peak occurrence between August and September, according to data reported by Global Forest Watch (2024).

This temporal concentration coincides with the dry season, when the accumulation of herbaceous biomass and the reduction of environmental humidity create conditions conducive to the spread of fire. The coincidence between Community perception and satellite data reinforces the validity of the ethnographic information collected and demonstrates that farmers and charcoal producers in the Alto Catumbela are qualified observers of environmental degradation processes affecting their parcels.

The community perception of the regular occurrence of fires in the Alto Catumbela finds resonance in studies carried out in other African savanna and dry grove ecosystems. In a study conducted in the Burkina Faso savanna park (Niemeijer & Mazzucato 2021) found that approximately 75% of the farmers interviewed recognized the anthropogenic origin of the fires, but continued to use fire for reasons of economic convenience and lack of viable alternatives. Similarly, in Mozambique, Sileshi and Mafongoya (2006) documented that the fires in the Zambian miombo are deliberately initiated by farmers, hunters and coal producers, replicating the pattern observed in Angola.

The results presented in Figure 3B show that about 82.11% of the fires are attributed to human action, according to the perception of the community surveyed. This high percentage shows that the population recognizes the influence of certain anthropogenic activities in the occurrence of fires. The perception about the origin of the fires reveals a significant environmental paradox, because although the community recognizes the anthropogenic origin of the fire and its negative effects on biodiversity, this perception does not necessarily translate into the adoption of sustainable fire management practices.

According to Cunha (2022), the recognition of the negative impacts of fires does not always correlate with changes in behavior in rural African communities, where economic, technological and sociocultural limitations perpetuate the use of fire as the main tool of land management. This dissociation between knowledge and practice is one of the main challenges for the integrated management of fire in Angolan miombo.

The main justifications for the use of fires persist for the economic, productive and socio-cultural reasons that encourage the continuity of this practice in the Alto Catumbela Sector. Cleaning fields by fire represents a low economic cost technique and immediate high yield in

terms of labor availability and ground preparation time. Muatendauafa & Cosme (2023) point out that in contexts of rural poverty and lack of technological alternatives, the use of fire persists as an adaptive mechanism in the face of the scarcity of financial resources for the preparation of crops. This reality is shared by multiple African miombo communities, where cutting-and-burn agriculture is the predominant system of land use.

Regarding the motivations for burning, the results presented in Figure 3C show that 62% of the respondents consider this necessary practice to facilitate the cleaning of agricultural fields, being widely accepted and used by the local community. Among respondents who develop livestock activities, the burning of vegetation is often justified as a strategy to promote the renewal of pastures and ensure the availability of fodder for livestock. In addition, some participants reported that fires may favor certain hunting activities. These results demonstrate that, despite awareness of the environmental impacts associated with fire, economic, productive and socio-cultural reasons that encourage the continuity of this practice in the Alto Catumbela Sector.

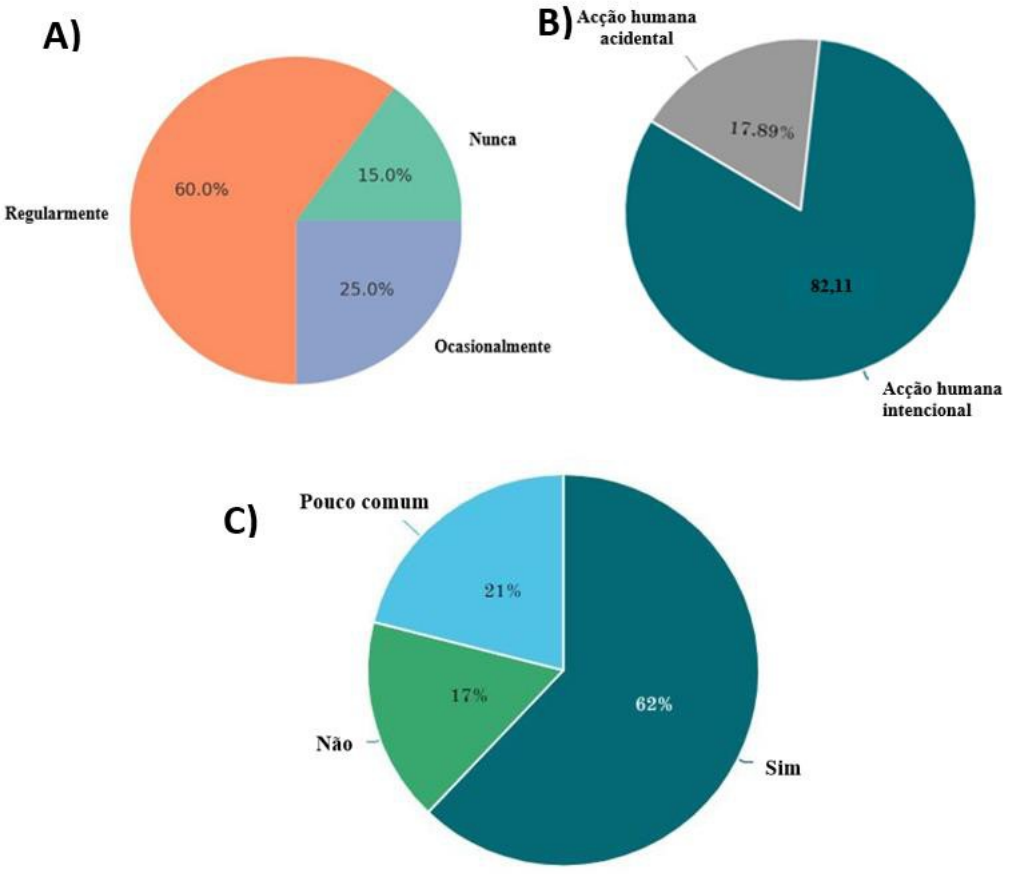

Figure 3 – Community perception of fires in the Alto Catumbela Sector. (A) Percentage of respondents confirming the regular occurrence of fires; (B) perception of the origin of fires, highlighting the predominance of human action; and (C) main justifications for the use of fire, namely clearing agricultural fields, renewing pastures, and supporting hunting activities.

Environmental Perception of the Community on the Impacts of Fires

More than 36% of homeowners acknowledge that fires have a moderate impact in the biodiversity of the fauna, while 52.63% of the respondents consider that these practices have a high impact on the faunal diversity after its occurrence (Figure 4A).

Similar results were observed in relation to the impact on productivity agricultural, where more than 63% of respondents recognize negative effects of fires on agricultural production (Figure 4B). These results corroborate the findings of Gonsalves (2005), which evidences a growing awareness among rural producers about the damage caused to the soil after successive cycles of fire use, namely the volatilization of nitrogen and the destruction of organic matter, factors that contribute to the reduction of long-term fertility (Cunha, 2022).

Regarding the perception of respondents about environmental education, the results show that only 5.2% have some knowledge in this area, while more than 94% claim to have never received training in environmental education (Figure 4C). These results reinforce the need to implement education and environmental awareness strategies oriented to integrated fire management, promoting more sustainable practices and reducing the incidence of uncontrolled fires in the community (Oliveira, 2025).

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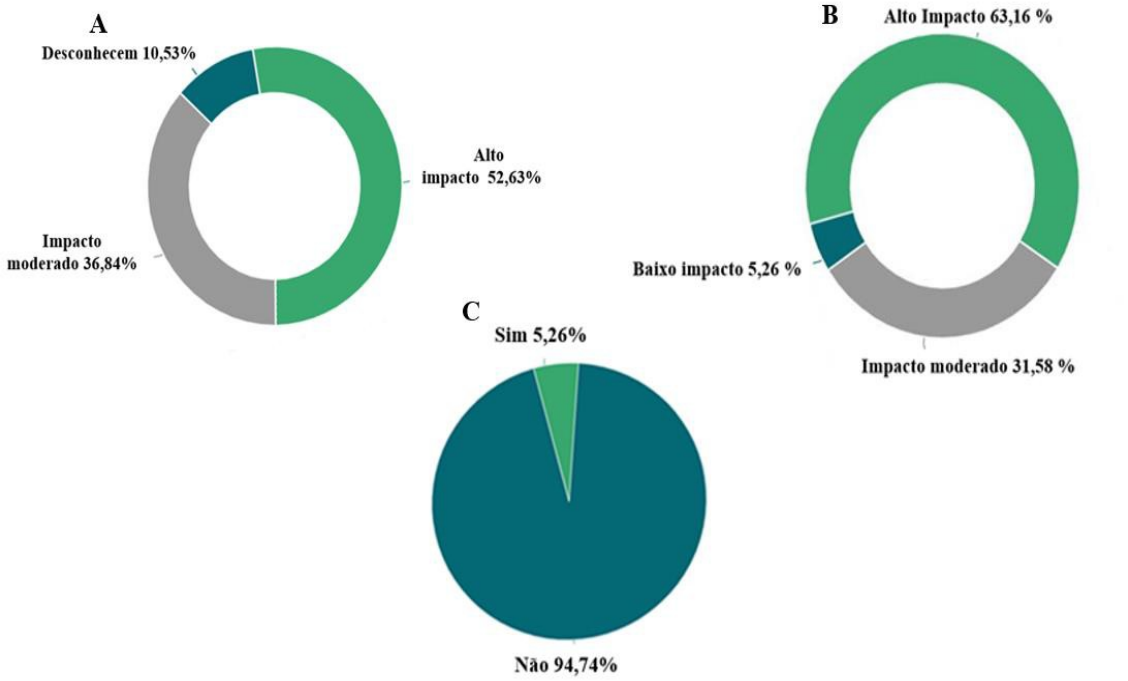

Figure 4-Perception of the community on the impacts of fires in the Alto Catumbela Sector. (A) Impact of fires on faunal biodiversity; (B) impact of fires on agricultural productivity; and (C) level of knowledge on environmental education in the community surveyed.

The farmers of the Alto Catumbela, through the empirical observation of decreasing incomes in plots subjected to repeated burning, internalized this cause-effect relationship. Nevertheless, the persistence of the use of fire is explained by the absence of alternatives viable technologies and the scarcity of financial resources for the implementation of sustainable soil management practices (Muatendauafa et al., 2023).

The recognition by more than half of the Alto Catumbela community about the negative impacts of fires on biodiversity and agricultural productivity coincides with trends documented in other miombo countries. In Mozambique, Chidumayo (2013) and collaborators have shown that repeated fires reduce the competitive capacity of mineo boreal species, particularly in low-fertility soils, which affects natural regeneration and grove structure.

On environmental education, the situation of the Alto Catumbela reflects a systemic lack present in much of the African continent. According to FAO (2010), Community fire management projects in the Mozambican miombo have successfully incorporated pre-fire-season annual capacity building programs, demonstrating that contextualized environmental education can significantly increase the participation of the rural community in the planning and execution of prescribed fire plans.

Biodiversity of Flora and Fauna Through Different Ecological Indices

Absolute and Relative Abundance of Sample Plots in Relation to Flora Type

A total of 400 individuals were found in the plots of the study area, revealing diverse vegetation predominantly composed of arboreal and shrub strata of the miombo. The 10 identified species belong to the genera *Brachystégia* and Julbernadia, namely *Pericopsis angolensis*, *Syzygium guineense*, *Steganotaenia araliacea*, *Uapaca kirkiana*, *Brachystégia* longifólia, *Parinari sp.*, *Brachystégia* spiciformis, *Ochna schweinfurthiana*, *Brachystégia* boehmii, and *Pterocarpus febrifugum* (Table 1). The most abundant species were *Pericopsis angolensis* (140 individuals), *Syzygium guineense* (52 individuals), and *Steganotaenia araliacea* (50 individuals), corresponding respectively to 14, 5.2, and 5 individuals/ha.

Likewise, Manjate & Massuque (2019), when analyzing the floristic composition and vegetation structure of the miombo savanna in different environments in the Sanga district, northern Mozambique, found an abundance of *Brachystégia* boehmii, *Syzygium guineense*, and *Pericopsis angolensis*. The same authors report that, in countries such as Mozambique, Tanzania, and Malawi, the genera *Brachystégia* and *Julbernardia* are characteristic of this type of ecosystem, which is consistent with the results obtained in this study, conducted in the Alto Catumbela Sector.

Table 1- List of flora species found in the plots of the studied area

Family	Scientific Name	Local Name	No of Individuals
Myrtaceae	*Sygium guineense*	*Akula-kula*	82
Fabaceae	*Pericopsis angolensis*	*Omako*	5
Fabaceae	*Brachystégia boehmii*	*Ussamba*	2
Myrtaceae	*Steganotaenia araliacea*	*Oloncha*	1
Fabaceae	*Psorospermum febrifugum spach*	*Oneko*	40
Myrtaceae	*Paripinari curatellifolia*	*Uchia*	8
Myrtaceae	*Uapaca kirkiana*	*Lombulwa*	1
Fabaceae	*Brachystégia spiciformis*	*Omanda*	12
Fabaceae	*Brachystégia longifólia*	*Ussombo*	16
Fabaceae	*Ochna schweinfurthiana*	*Omia*	12
Myrtaceae	*Sygium guineense*	*Akula-kula*	31

Fabaceae	*Pericopsis angolensis*	*Omako*	1
Fabaceae	*Brachystégia boehmii*	*Ussamba*	1
Myrtaceae	*Steganotaenia araliacea*	*Oloncha*	1
Total		**400**	

Similarly, Nanvonamuquitxo (2019) recorded a greater representation of species of the Fabaceae family when analyzing the structure and diversity of a miombo forest in Taratibu, northern Mozambique, a pattern consistent with the results obtained here. The presence of *Syzygium guineense* as the second most abundant species in Alto Catumbela coincides with reports of it as a frequent species in humid miombo in Zambia and Tanzania, where it has significant Importance Value Index (IVI) values (Kalaba et al., 2013). In Tanzania, this species was reported as highly exploited for its quality timber and as being commercially extinct in areas of high use (Whittaker et al., 2014). Its dominance in Alto Catumbela could be interpreted both as an indicator of resilience to fire and as a warning sign of the selective pressure exerted by timber extraction, since charcoal producers may avoid cutting it because of its commercial value or cutting difficulty, allowing its demographic accumulation.

Floristic Sample Sufficiency

To verify the sample sufficiency in relation to the inventoryed flora, the species accumulation curve was determined, also called the collector curve. The analysis of the curve revealed that from the plot No. 7 the tipping point was reached, that is, the subsequent plots stopped registering new species, indicating that the sample made is representative for the 10 hectares inventoryed and that, under the environmental conditions studied, the appearance of new species is unlikely (Figure 5).

In the present study, early stabilization of the curve is associated with the fact that it is a deciduous miombo forest with evident indications of human disturbance, namely, the recurrent fires, which reduces the floristic diversity and accelerates the stabilization of the curve. The behavior observed in the Alto Catumbela differs from that reported by João (2016), whose reference study was conducted in a semi-deciduous miombo forest without human disturbance in Mozambique, where the greater floristic diversity required a higher number of plots to achieve the stabilization of the species accumulation curve.

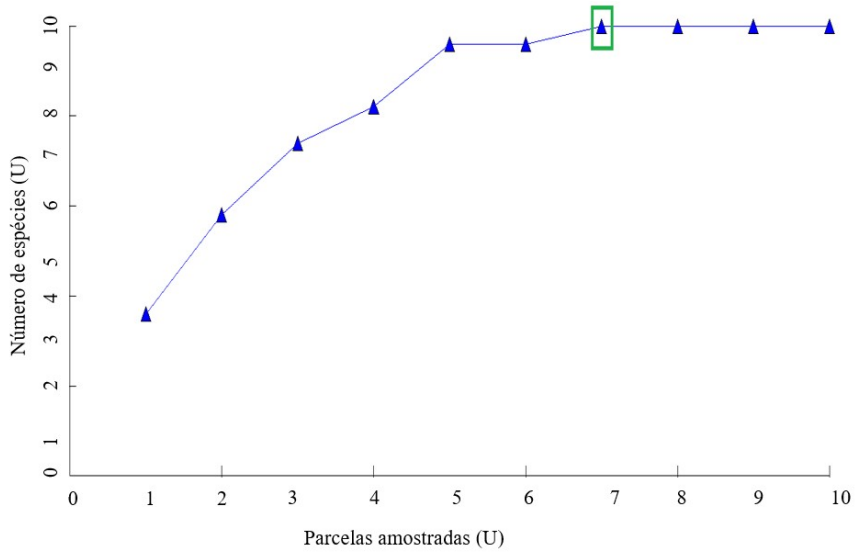

Figure 5- Curve of accumulation of species (curve of the collector) registered in the sector of the Alto Catumbela.

Ecological Parameters of Flora

The diversity of species in the study area, measured by the Shannon diversity index (H'), presented values below 2 in all plots, ranging from 0.66 to 1.33 (Table 2), which indicates a low diversity in the ecosystem studied Mate et al. (2014). The results of the Shannon index of the present study are close to those found by Vilanculos & Mucudos (2013), (1.2 to 1.4) and Almeida (2015), (1.59 to 1.96) , which report Shannon values in an evergreen mountain forest of the Moribane reserve. However, these results differ from those reported by João (2016) who obtained higher values (3.07 and 3.90) for the semi-deciduous miombo forest without disturbance in Mozambique. This discrepancy reinforces the hypothesis that anthropogenic disturbance drastically reduces Shannon's diversity by eliminating rare and exclusive species of certain plots (Fischer, 2014).

In Tanzania, Shirima et al. (2011) obtained Shannon indexes of 1.05 and 1.25 in miombo woods, while in landscapes of western Usambara, Munishi et al. (2008) reported diversities of 2.7. In the miombo of Zambia, Kalaba et al. (2013) found values of 2.8 in mature woods, showing that the diversity of the Alto Catumbela is located at the lower end of the regional range. This extreme position in the diversity gradient can be explained by the combination of recurrent fire, wood extraction and biogeographical isolation of the studied forest.

The Simpson index indicated the existence of ecological dominance in the study area, with values close to 0.4 in most plots. This result suggests a probability of about 40% of two randomly selected individuals belonging to the same species, showing a greater predominance

of some species, such as *Pericopsis angolensis* (Fabaceae family). By comparison, studies in tropical wetlands of Nigeria reported Simpson (1-D) values of 1.86 in undisturbed forests, while in forests with disturbances the values were extremely low (0.033), evidencing the sensitivity of this index to the disturbance (Springer, 2025).

The Simpson Reciprocal Index (1/D) ranged from 2.17 to 4.40, and the P1 portion presented the highest value (1/D = 4.40), this value shows greater specific diversity and lower ecological dominance. However, the P5 plot registered the lowest value (1/D = 2.17), this value suggests that the plot is dominated by few species. In general, the observed values of the Simpson Reciprocal Index indicate a moderate to high diversity between the plots, there are differences in the composition and distribution of the species.

Regarding the specific wealth, expressed by the Margalef index (Dmg), there was low wealth in all plots, with values between 0.09 and 1.13 (Table 2). The plot 8 presented higher relative richness, associated with the higher number of species (S=5), while the portion 1, despite having equal number of species, revealed a reduced value of the index, due to the high total number of individuals (N). These results are in line with ecological studies that highlight the importance of the combination of wealth and distribution of abundances in the characterization of biological diversity (Magurran, 2004)

The Menhinick index ranged between 0.47 (parcel 2) and 0.83–0.85 (plots 7 and 8), indicating, in general, low specific wealth. Part 8 stood out for having greater relative diversity, showing a more balanced relationship between the number of species and the total number of individuals.

With regard to the equitability of Pielou, the values found in the Alto Catumbela, (J' = 0.739-0,951) are comparable to those reported by Manjate et al. (2025), in Mozambique (Pielou = 0.6). On the other hand, these values are lower than expected for mature forests where the distribution of individuals between species is more equitable.

Table 2 - Flora diversity indexes per sampling portion: Shannon Diversity Indexes (H'), Margalef (Dmg), Menhinick (Dmn), Simpson (D), Simpson reciprocal (1/D) and Pielou (J').

Parcel	In Indiv.	Shannon (H')	Simpson (D)	1/D	Margalef (R)	Dmn (Menhinick)	Pielou (J')
P1	43	1,660	0,227	4,40	0,09	0,52	0,948
P2	140	1,333	0,278	3,59	0,701	0,47	0,951
P3	26	1,191	0,429	2,33	0,798	0,61	0,873

P4	12	0,887	0,296	3,38	0,800	0,87	0,836
P5	18	0,918	0,461	2,17	0,69	0,70	0,889
P6	40	1,234	0,318	3,15	0,81	0,63	0,891
P7	23	1,229	0,262	3,82	0,95	0,83	0,944
P8	34	1,116	0,457	2,18	1,13	0,85	0,739
P9	**34**	**1,251**	**0.313**	**3,19**	**0.85**	**0.68**	**0.930**
P10	30	1,055	0,428	3,33	0,88	0,73	0,841

Diversity of Sample Plots in Relation to Fauna Type

Based on the data collected, the studied area presents a faunal community dominated by invertebrates, with emphasis on insects of different orders, in addition to some representatives of arachnids, molluscs and amphibian vertebrates. In total, 213 individuals (Table 3) were registered, distributed in various taxonomic categories, which reflects a typical ecological structure of tropical terrestrial environments (Stephen, 2001).

There was a high abundance of insects, particularly groups such as locusts of the genus (*Locusta sp.*, n=82), cockroaches (*Blaptica dubia*, n=40) and termites (*Odontotermes sp.*, n=31). The abundance of cockroaches, grasshoppers and termites observed in this study is in line with that described by Jouquet al. (2011), which highlight the termites as key organisms in tropical ecosystems, especially in savannah environments and open forests, where they contribute significantly to nutrient cycling and soil structure modification. The predominance of these groups suggests that the area has edaphic and climatic conditions favorable to decomposing activity, which is typical of environments with accumulation of organic matter (Roh, 2024).

In Mozambique, studies on the distribution and diversity of termites in different land uses have shown that these insects are sensitive to disturbance, but that certain opportunistic genera such as Odontotermes can maintain high populations in degraded areas (Science Publishing Group, 2022).

The presence of predators such as spiders (*Latrodectus sp.*) and true bugs (*Reduvius acanthaspis* and *Podisus nigrispinus*), although in low abundance, indicates the existence of higher trophic levels. The low abundance of amphibians in the sampled plots, compared with

other studies in humid miombo woodlands where amphibians such as *Amietophrynus* are more frequent, reflects the reduction in humid microhabitats associated with recurrent fires, since amphibians are highly sensitive to environmental changes and function as bioindicators of ecological integrity (Grant, 2016). Additionally, the presence of millipedes (*Archispirostreptus gigas*) and lepidopteran larvae (*Spodoptera sp.*), although in low abundance, reinforces the existence of decomposition-based food chains, as described in studies of evolution and ecology (Nimmo, 2015).

Table 3 - Faunistic composition and abundance of species registered in the Alto Catumbela sector.

Scientific Name	**Local Name**	**No of Individuals**
Locusta sp.	Gafanhoto	82
Latrodectus sp.	Aranha	5
Ordem Lepdopteta	Borboleta diurna	2
Achatina fulica	Caracol	1
Blaptica dúbia	Barata	40
Strategus sp	Scaravelo	8
Spodoptera sp.	Larva	1
Grillus assimilis	Grilo negro	12
Reduvius acanthaspis	Percevejo	16
Systerme grandis	Cupim grande	12
Odontotermes sp.	Salalé	31
Archispirostreptus gigas	Milípede africano	1
Epipedobates tricolor	Sapo-do-mato	1
Podisus nigrispinus	Percevejo	1
Total		**213**

Indices of Fauna Diversity Per Sampling Parcel

Table (4) presents the values obtained for each sampling portion of the faunal composition; the results of the ecological indices, in most of the plots presented moderate diversity, with Shannon values between 0.61 and 1.92. The P8 portion, which presented the highest values of Shannon's diversity (H' = 1,929) and Margalef richness (R = 1.15), which indicates high faunal diversity, a result associated with the higher number of species (S = 7) and a relatively balanced distribution of individuals.

This figure indicates a structurally more complex and ecologically stable community (Yizhou, 2024). On the other hand, plots 9 and 10 showed values below 0.70, which indicates low diversity and predominance of few species, which may be related to factors such as habitat limitation, environmental pressure or reduced ecological heterogeneity.

The plots such as P6 (H' = 0.682; D = 0.511) and P3 (H' = 0.867; D = 0.499) showed high dominance and low diversity, which suggests the predominance of few species.

The Simpson index (D) results indicated higher species dominance in all plots suggesting concentration of individuals in a few species, while plot 1 has lower dominance (D = 0.12), reflecting a greater relative distribution among the species present. The analysis of the reciprocal index (1/D), was higher in P1 (8.26) and has the highest effective diversity, however, the plots 9 and 6 have lower values, reinforcing greater dominance.

However, the Margalef index ranged between (0.09) P6 and (1.15) P8, the highest number of wealth was observed in Parcel 8, thus confirms the pattern already identified in the Shannon index, and reinforces that this portion has strong faunal heterogeneity. The high values of Pielou varied between (J' = 0.983) in P6, (J' = 0.894) P5 e(J' = 0.09) P3. Parcel 6 showed high equitability, which indicates almost uniform distribution of individuals among species, despite the low number of species (S = 2).

The plots (10, 7 and 4) showed reduced values, which indicates lower specific wealth proportional to the total number of individuals, so the community is less diverse. The presence of predators, such as spiders (*Latrodectus sp.*) and bedbugs (*Reduvius acanthaspis* and *Podisus nigrispinus*), although in smaller numbers, is ecologically relevant, contributes to the regulation of insect populations. According to (Ulrich, 2019), the reduction of predators in simplified ecosystems can lead to the increase of dominant species and the decrease of ecological stability.

Table 4 - Indices of fauna diversity per sampling portion.

Parcel	S	In Indiv.	Shannon (H')	Simpson (D)	1/D	Margalef (R)	Dmn (Menhinick)	Pielou (J')
P1	4	33	0,867	0,121	8,26	0,858	0,70	0,620
P2	3	42	0,896	0,481	2,08	0,053	0,46	0,271
P3	3	6	0,867	0,499	2,01	0,333	1,22	0,090
P4	**4**	**22**	**1,273**	**0.300**	**3,32**	**0.136**	**0.85**	**0.660**

P5	3	25	0,982	0,368	2,72	0,08	0,60	0,894
P6	2	26	0,682	0,511	1,96	0,038	0,39	0,983
P7	3	10	0,943	0,420	2,38	0,20	0,95	0,859
P8	7	37	1,929	0,289	3,46	1,15	1,66	0,753
P9	2	10	0,610	0,580	1,72	0,635	0,63	0,423
P10	2	2	0,637	0,554	1,80	0,111	0,67	0,441

Final Considerations

The results show that the High Catumbela Sector community recognises the negative impacts of fires on biodiversity and agricultural productivity. However, the use of fire remains a recurring practice in agricultural activities, showing a contradiction between the perception of impacts and the behavior adopted. The low level of training in environmental education reinforces the urgent need for awareness- and training programs that promote sustainable fire management practices.

The analysis of the ecological indices in the ten sampling plots revealed moderate levels of biodiversity, both in the floristic and faunal community, with a hete-rogeneous structure between plots. The fauna community presented greater variability of alpha diversity compared to the floristic community. The observed patterns reflect anthropogenic disturbance associated with recurrent fires.

An ecological restoration plan was developed oriented to the recovery of mineo-tas flowers with degradation, contemplating reforestation actions with native species, fire use control and biodiversity monitoring, with a view to restoring the structure and functionality of the ecosystems affected in the Alto Catumbela Sector.

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