

## RESEARCH ARTICLE

# Assessment of livelihood and participation of Mutoe communities in the management and conservation of forest resources in the Moribane Forest Reserve, Sussundenga - Mozambique

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## ABSTRACT

Forest land provides several environmental services and goods with significant implications for different socioeconomic and environmental dimensions. The participation of local communities in the management of natural resources, including forests, is essential for their conservation. This paper aims to analyze the subsistence conditions and level of participation of the Mutoe community in the management of forest resources in the Moribane Forest Reserve (MFR). The study was carried out using a combination of methods: (i) a social survey through interviews with 41 people out of 200 households living within the Mutoe village to understand the socio-economic aspects related to families' livelihoods. The Chimanimani National Park's management was questioned to understand the contours of the management process; (ii) Interpretation of images from Google Earth Pro Satellite Data to verify changes that occurred between 2007 and 2022 and; (iii) direct field observation carried out to compare and validate information resulting from the interviews and the interpretation of Google Earth Pro images with the help of a bibliographic review. The results showed that close to 80% of the population of the Mutoe village lives in precarious conditions and their main subsistence base is shifting agriculture. Its participation in the management of natural resources is weak and; between 2007 and 2022 there was a considerable reduction in vegetation cover in almost the entire area of the reserve which includes Mutoe village. The study can help the academic community in future studies by replicating the methodology used for monitoring purposes or conducting studies in other similar areas, and the results may support decision-makers in designing better strategies toward sustainability.

**Keywords:** natural resources; livelihood; community participation; management and conservation; vegetation cover

## 1. Introduction

The Forest woodland constitutes a habitat and a key provider of goods and services<sup>[1]</sup>. Its structure and composition are strongly determined by their woody component, particularly by large trees, which play a key

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role in ecosystem function, generate services that contribute with tangible and intangible benefits to a range of human well-being<sup>[2,3]</sup>. Pressures from human activities leading to forest loss, fragmentation, and degradation<sup>[16]</sup> have already caused much biodiversity decline and homogenization<sup>[4]</sup>. These declines are expected to continue<sup>[5]</sup>, especially in the rich forests of Central and South America, South and Southeast Asia, and Africa, although the rate of forest loss has been slowing in recent years<sup>[6]</sup>.

The Stockholm Conference held in 1972 recognized forests as the largest complex and most durable of all ecosystems, which is why global efforts have been made to value the importance of forests and promote their sustainable management<sup>[7]</sup>. This conference raised awareness of the fact that a large part of the forest cover had already been cut down and therefore recommended the need for rational land and forest use policies, continuous monitoring of their status, and better forest management planning<sup>[8]</sup>. However, these recommendations are not being fulfilled due to conflicts of interest between forest management aimed at environmental conservation and management aimed at economic development<sup>[9]</sup>.

The latest study by the Food and Agriculture Organization of the United Nations (FAO) on forest resources points out that over the last 25 years, the forest area has reduced from 4.1 billion to just under 4 billion hectares, a reduction of 3.1%. The same study reveals that the rate of global change in forest areas was more than 50% between 1990 and 2015<sup>[10]</sup>. For this and more reasons, the need to protect forests is becoming increasingly recognized, causing the area of forest that is protected through parks and reserves to grow globally. However, the level and conservation efforts remain negligible about the rate of deforestation in the country, meaning that efforts of different types involving different actors, namely the government and its partners, as well as non-governmental organizations and private institutions, are increasingly necessary with the direct support of local communities.

The conservation and participatory management of natural resources, which include forests, currently constitute a recurrent path towards self-sustenance, combating poverty, and rational use of natural resources<sup>[11-13]</sup>. Such facts are due to the growing recognition that different actors, including the State, the private sector, and local communities, play their roles with zeal when they see their combined efforts, compared to the results obtained by each of these actors separately<sup>[8]</sup>.

The relevance of participation in the management and conservation of natural resources was highlighted in Agenda 21, by advocating the integration between the environment and development in political, planning, and management plans, recommending above all the promotion of public participation in all spheres of life, to guarantee sustainable development. In this context, it is urgent to promote the training of local communities to obtain sustainable means of subsistence<sup>[14]</sup>.

According to Peng<sup>[15]</sup>, forests are dynamic biological systems that are continuously changing. Deforestation is one of the most relevant global environmental concerns today, especially with the growing recognition of the role of these ecosystems in the carbon cycle and the possible mitigation of climate change<sup>[10]</sup>. The over-exploitation of natural resources due to the increase in demand for ecosystem services combined with the belief of local communities and their leaders in the past about the self-resilience of resources regardless of their unsustainable use through subsistence practices have contributed considerably to the current stage of deforestation in the country<sup>[16]</sup>. These practices included slash-and-burn agriculture, felling trees for housing construction, charcoal production and the manufacture of handicraft objects, and hunting, among other practices, currently considered harmful to the conservation of the forest and natural resources in general<sup>[17]</sup>. The main source of energy in rural areas is wood fuel extracted from forests, normally used to prepare food and produce alcoholic and non-alcoholic drinks for heating in winter, among other uses<sup>[9]</sup>.

Human beings have been identified as the main agent of destruction and impoverishment of natural forests, motivated by the need to increase food production fields and extract various products to meet their needs aggravated by population growth<sup>[18]</sup>. In this regard, according to the World Bank report, more than 90% of families in developing countries depend exclusively on natural resources for their survival. In the particular case of Mozambique, around 80% of the Mozambican population lives in rural areas and depends on the exploitation of natural resources for their subsistence, being dependent on access to land, forest resources, water, and fishing, among other resources<sup>[16]</sup>.

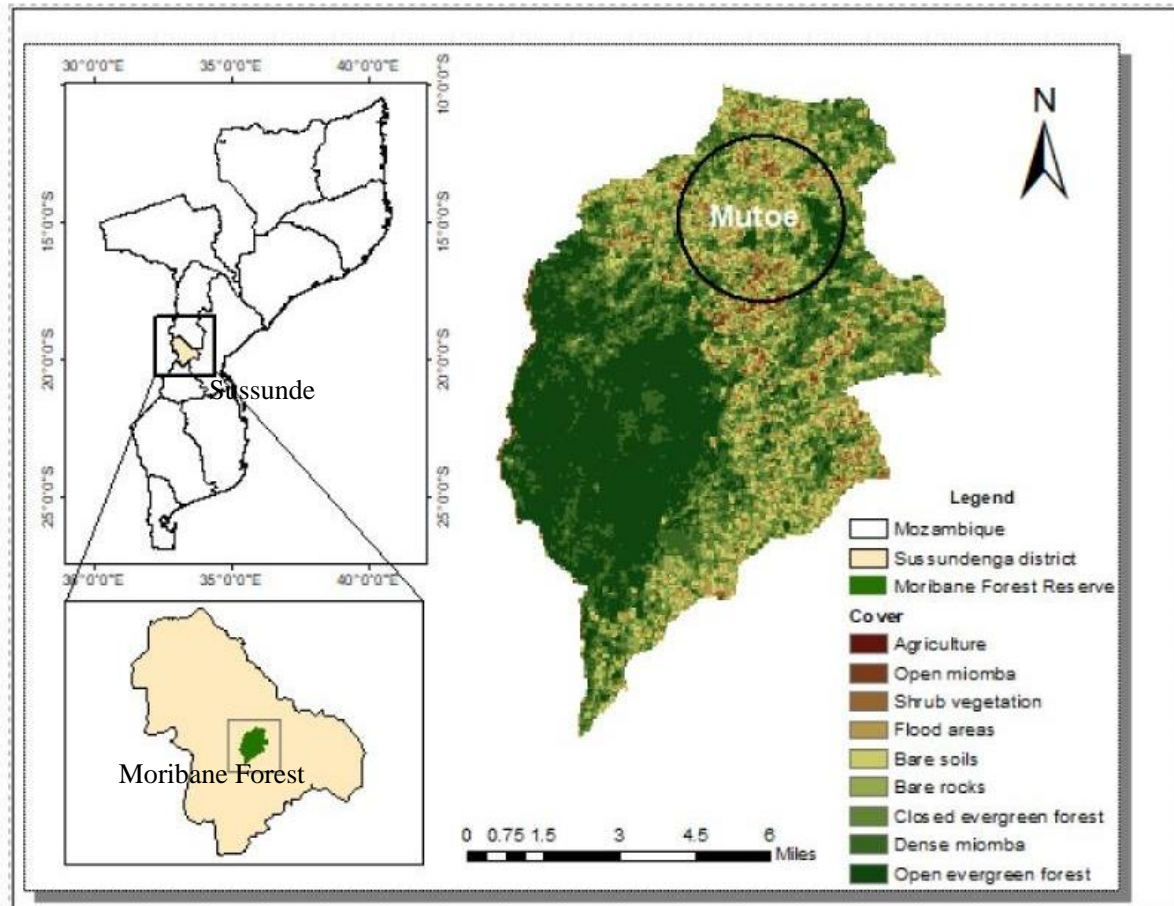
According to Saket<sup>[19]</sup>, the country's most recent forest inventories reveal that deforestation in Mozambique has been increasing at worrying rates. From 1972 to 1990 the deforestation rate was estimated at 0.21 percent each year, while from 1990 to 2002 the deforestation rate was around 0.58%, corresponding to 219 thousand hectares/year<sup>[20]</sup>. According to Siteo et al.<sup>[7]</sup>, between 2003 and 2013 the deforestation rate was 0.79% which corresponds to the loss of 267029 hectares of forest area per year with consequent loss of ecosystem services. Recent estimates show that, if the necessary measures are not taken, the national deforestation rate could reach 1.4 percent (528.6 thousand hectares) in 2025, which reveals the seriousness of the situation<sup>[7]</sup>. In Mozambique, land is the property of the State and cannot be sold, alienated, or seized (Law n° 1/2004). However, legislation (Law n° 19/97, of October 1st - Land Law and Law n° 10/99 of July 7th, Forestry and Wildlife Law) recognizes the rights of local communities over the use of natural resources, of the lands they occupy according to customary norms and practices as well as the rights to delimit and register them.

The main objective of this study is to analyze the subsistence conditions and degree of participation of the Mutoe community in the management of forest resources in the Moribane Forest Reserve. The authors hypothesize that all families' basic subsistence needs are ensured by the ecosystem services provided by the MFR's forest resources, although their level of participation in their management is weak and that the vegetation cover of the area has been progressively degrading between 2007 and 2022. This research seeks to answer: (i) What are the subsistence conditions of families living in Mutoe? (ii) What is the stage of community participation in the management and use of forest resources? (ii) What are the changes in vegetation cover that occurred between 2007 and 2022?

## **2. Materials and methods**

### **2.1. Description of the study area**

The village of Mutoe is located 19° 45' South and 33° 22' East of the buffer zone of the Moribane Forest Reserve, in the Dáruè locality, Dombe Administrative Post, Chimanimani National Park, Sussundenga district, Manica province<sup>[21]</sup>. See the geographic location of Mutoe in **Figure 1** below:



**Figure 1.** Geographic location of the Mutoe community within the Moribane Forest Reserve (perimeter in white), buffer zone of the Chimanimani National Park in the Sussundenga district. Coordinates: S19 41'45.0" and E033 20'56.9".

Source: [22]

### 2.1.1. Population and economic activities

According to Monteiro et al.<sup>[5]</sup> and Timberlake et al.<sup>[11]</sup>, Mutoe village is the most populous in the Moribane Forest Reserve (MFR) with around 200 families, mostly young people attracted by the location and construction of National Road no. 260, which facilitates the flow of its main agricultural product (bananas). The main economic activity is shifting cultivation, which has contributed greatly to deforestation and forest degradation. FEWS NET<sup>[23]</sup> and USAID, 2018<sup>[49]</sup> in addition to the production of charcoal for sale, tourist activity is developed by the Kubatana Moribane community association, in cooperation with the Ndzou Camp Organization<sup>[24]</sup>.

### 2.1.2. Climate

According to the Koppen classification, the predominant climate in the Sussundenga district is a tropical rainy Savanna climate, with two distinct seasons, the rainy season and the dry season. The average annual precipitation at the nearest station is about 1,171 mm, while the average annual potential evapotranspiration is 1,271 mm.

The greatest rainfall occurs in the period between November of one year and March of the following year, varying significantly in quantity and distribution and the average temperature is in the order of 23.0°C. The maximum and minimum annual averages are 29.5°C and 17.6°C, respectively.

### 2.1.3. Relief

The central area of the Sussundenga district is characterized by Undifferentiated Afromountain-type relief, which is part of the center of Zambezi regional endemism, whose altitudes are around 1500m. The district is predominantly composed of rocky outcrops in the form of inselbergs, valleys, and/or depressions.

### 2.1.4. Soil

The influence of climate and geology defines the soil typology of this district. Geomorphologically, the territory of the Sussundenga District partially occurs in the vast Gneisto – Mozambique Granitic “Belt” complex where the Post – Karro Intrusive rocks stand out in the form of inselbergs. This form of terrain results in different groupings of soils, notably red clayey, red sandy and medium-textured red soils, and lithic soils. These soils, except lithic ones in general, are moderately deep, neither saline nor sodium. Soils with a predominantly clayey texture have good nutrient and water retention capabilities, while sandy soils are not very fertile.

### 2.1.5. Vegetation

Miombo is the predominant vegetation in the study area. The riverine forest, evergreen and semi-deciduous at low altitudes and grasslands, constitute forest gradients where species such as Umbila (*Pterocarpus angolensis*), Panga-Panga (*Millettia stuhlmannii*), Pau-Preto (*Dalbergia melanoxylon*), and Chanfuta (*Azelia quanzensis*) stand out. The region has a variety of beautiful landscapes and picturesque settings that consist of mountains, high plateaus, forests, rivers, waterfalls, lagoons, and a high biodiversity of animals and plants. It is important to note that this beautiful landscape has been severely damaged by uncontrolled fires caused by local communities.

## 2.2. Data collection

The data collection took place between September 22<sup>nd</sup> and October 20<sup>th</sup>, 2022 and involved a combination of methods.

### 2.2.1. Semi-structured interviews

To understand the socio-economic aspects related to the subsistence of families in the Mutoe communities, a semi-structured interview was carried out with 40 heads of households. This sample included three members of the community leadership and the universe of interviewees could be male or female depending on who was found and who was available at the time. This sample represents 20% of the approximately 200 households living in this community, a number considered sufficient in social research according to<sup>[25]</sup> and<sup>[26]</sup>. The interviews aimed to understand (i) the history, profile, and socio-economic condition of the households; (ii) subsistence activities and family food security, and (iii) the source of resource extraction and the level of knowledge they have about coexistence in a region belonging to a natural resource conservation area. From the interviews, the knowledge of local communities about their participation in Natural Resource Management in the Moribane Forest Reserve (MFR) was also explored.

The interview was also administered to the managers of the Chimanimani National Park (CNP) with a view to understanding: (i) the main activities carried out by the CNP in the MFR; (ii) The rights and duties of Buffer Zone (TZ) communities; (iii) Functioning of natural resources management committees (NRMC); (iv) Level of community participation in the NRMC at the MFR level; (v) the NRMC management model; (vi) Incentives for communities; (vii) frequency of environmental education forums and; (viii) inspection activities. See **Table 1** below for the sample population:

**Table 1.** Sample population from the community of Mutoe-MFR, CNP.

Target groups		Sample
	Residents	37
Communities	Leaders	3
CNP Employee		1
Total		41

### 2.2.2. Image interpretation using *Google Earth Pro*

Regarding the conditions of the biophysical environment of the Mutoe region, a visualization of the forest cover of this region was made through images accessed through the *Google Earth Pro* platform. Before the process, the study region was demarcated using shapefile (*in ArcGiz's KMZ format*) and opened in *Google Earth Pro*. Next, the perimeter of the Mutoe region, a community north of the MFR, was drawn using the Polygon tool. Further, using the show historical imagery tool, three images from the last 15 years were viewed, namely 2007, 2011, and 2022. The irregularity in the intervals was due to the quality of available images. Finally, the images were recorded for later description. According to Assis<sup>[27]</sup>, *Google Earth* allows the generation of cartographic products at a scale of 1:25,000 and larger, proving to be a very effective tool as a support base for planning and decision-making. However, this tool has limited use for engineering projects and cadastral updates.

### 2.2.3. Direct field observation

This method was used to explore field details to compare and validate the aspects reported by the communities during the semi-structured interviews. This method was also used to assist in the interpretation of satellite images relating to changes that occurred over the years in the interval under analysis (2007-2022). According to Chalmers<sup>[28]</sup>, observation consists of using the senses to obtain specific information about some aspect of reality. It assumes the rigor of the method and the importance of rules and criteria that establish it<sup>[29]</sup>. Through the observation technique, concrete evidence is sought that is capable of reproducing the phenomena under study in their fundamentals, obtaining the maximum amount of information, and learning about the object under analysis. This evidence, in convergence with other techniques and tools, allows for a more dynamic and faithful understanding of the observed reality<sup>[13]</sup>.

### 2.3. Validation of hypotheses

The validation of the hypotheses was carried out by induction. Induction is the process by which we can obtain and confirm general hypotheses and statements from field observations and the trend of results through the frequency table<sup>[4]</sup>. Induction was used to confirm or refute through the trend of interview results on (i) the opinion of households regarding their socio-economic conditions for the satisfaction of basic needs; (ii) their level of participation in resource management and; (iii) through the degree of changes in vegetation cover visualized in the images and referring to the time interval under analysis (2007-2022).

### 2.4. Data processing and analysis

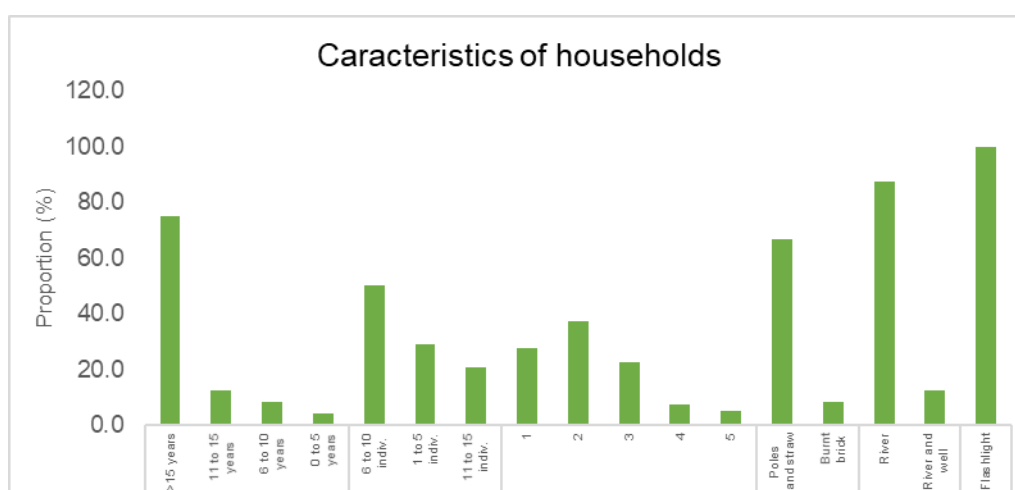
Community interview survey data were processed by grouping similar responses and calculating their percentage. Then, the responses were coded and frequency polygons were constructed in a *Microsoft Excel* package. Regarding the questionnaire administered to the Park's structures, the key answers were summarized in simple tables.

The images relating to changes in land use and coverage over the last 15 years, that is, 2007 -2022, were interpreted based on variations in green and brown tones that represent the intensity of changes in coverage given the dynamics of its use for different purposes. Its interpretation was based on the history contained in the management plan and other research carried out in the past regarding the area in question.

### 3. Results

#### 3.1. Identification of socio-economic aspects related to family subsistence

The majority of households (75%) have lived in Mutoe for more than 15 years; are made up of between 6 and 10 members (50%); live in precariously constructed houses built on poles and straw (66.7%); they drink water from the river (87.5%) and use flashlights for lighting inside their houses (87.5%). As for education, a considerable proportion (37.5%) of household members have a primary level of 1st-grade<sup>1</sup> followed by those who never had the opportunity to have been in a formal education<sup>2</sup> (27.5%) and those with a Primary level of 2nd-grade<sup>3</sup> (22.5%). A very low proportion of household members with basic secondary<sup>4</sup> (7.5) and medium secondary level<sup>5</sup> (5.0%) was observed, as shown in **Figure 2**.



**Figure 2.** Characteristics of households assessed through residence time, number of members, level of formal education, type of houses, source of water collection for consumption, and source of lighting in Mutoe.

#### 3.1.2. Household food security

A considerable number of respondents (79.2%) have three meals a day; the months of food scarcity vary by family depending on the other alternative source of subsistence; Among the main activities that generate family income are beekeeping<sup>6</sup>, banana production<sup>7</sup>, agriculture<sup>8</sup> (cereals) and livestock farming<sup>9</sup>. Bananas and honey are mainly intended for sale and constitute activities that generate greater income for families.

<sup>1</sup> Primary level of 1st grade - this is represented by the number 1 in the “education level” section of the chart.

<sup>2</sup> Illiterate - this is represented by the number 2 in the “education level” section of the chart.

<sup>3</sup> Primary level of 2nd grade - this is represented by the number 3 in the “education level” section of the chart.

<sup>4</sup> Basic secondary - this is represented by the number 4 in the “education level” section of the chart.

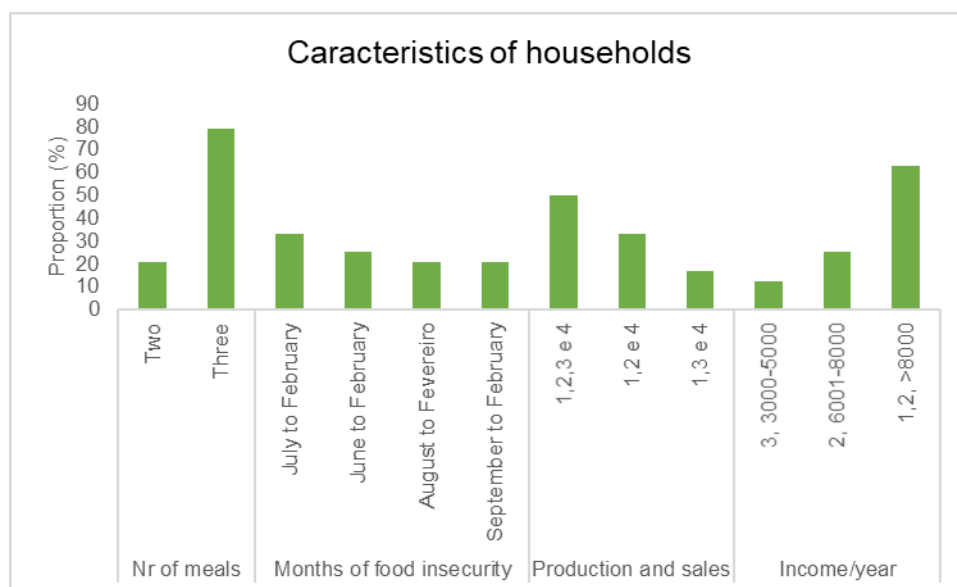
<sup>5</sup> Medium secondary - this is represented by the number 5 in the “education level” section of the chart.

<sup>6</sup> Beekeeping - this is represented by the number 1 in the “Production and sale” section of the chart

<sup>7</sup> Banana production - This is represented by the number 2 in the “Production and sale” section of the chart

<sup>8</sup> Agriculture - this is represented by the number 3 in the “Production and sale” section of the chart

<sup>9</sup> Livestock - this is represented by the number 4 in the “Production and sale” section of the chart



**Figure 3.** Characteristics of households assessed through a number of daily meals, food security, production and marketing, and household incomes.

### 3.1.3. Source of extraction of resources and local knowledge

There is a lot of availability of firewood among fallow lands<sup>10</sup> and farms/*machambas*<sup>11</sup> (87% of respondents), meaning that forests do not feel the pressure to demand these services. The majority (70.8%) of clearing areas for agricultural production is done using a hoe, ax, and others<sup>12</sup> instead of burning<sup>13</sup> (20.8%) and using tractors<sup>14</sup> (8.3%). It was also observed that there was a lot of knowledge regarding the importance of forests (87.5%) as a habitat for fauna<sup>15</sup>, a source of food (NTFP- non-timber forest products which include tubers, medicinal plants, mushrooms, hunting of small mammals such as rats, etc.)<sup>16</sup>, and of energy<sup>17</sup>. A considerable proportion of households (66.7%) are aware of legal limitations on access to natural resources<sup>18</sup> as illustrated in **Figure 4** below:

<sup>10</sup> This is represented by the number 1 in the “firewood acquisition locations” section of the chart

<sup>11</sup> This is represented by the number 2 in the “firewood acquisition locations” section of the chart

<sup>12</sup> This is represented by the number 1 in the “Techniques for opening *machambas*” section of the chart

<sup>13</sup> This is represented by the number 2 in the “Techniques for opening *machambas*” section of the chart

<sup>14</sup> This is represented by the number 3 in the “Techniques for opening *machambas*” section of the chart

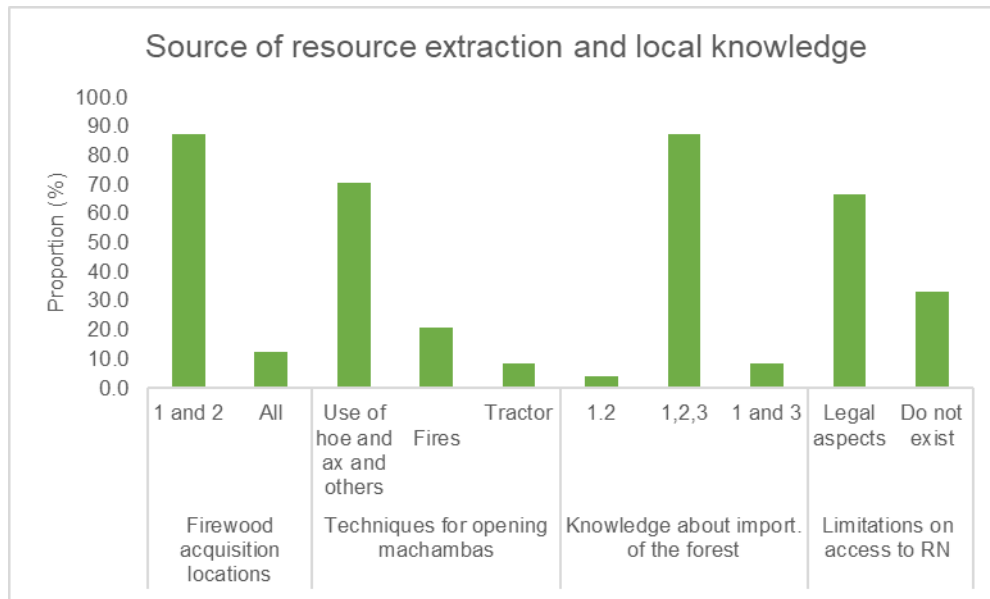
<sup>15</sup> This is represented by the number 1 in the “Knowledge about the importance of the forest” section of the chart

<sup>16</sup> This is represented by the number 2 in the “Knowledge about the importance of the forest” section of the chart

<sup>17</sup> This is represented by the number 3 in the “Knowledge about the importance of the forest” section of the chart

<sup>18</sup> This is represented by the number 1 in the “Limitations on access to NR” section of the chart





**Figure 4.** Characteristics of households assessed through firewood acquisition locations, techniques for opening small fields of crops in family production ("Machambas" in Portuguese), and knowledge about the forest, rights and duties.

### 3.2. Participation of the Mutoe community in the management and use of forest resources

Communities divide opinions regarding attendance in forums relating to community development projects in which 45.8% participated sometimes<sup>19</sup> and 29.2% would never have participated<sup>20</sup>, with those who always participated representing<sup>21</sup> only 20.8%. Regarding knowledge about the CNP's Moribane Forest Reserve, and their rights and duties as a population of the BZ, everyone (100%) knows that Mutoe belongs to MFR. In this regard, they assumed that, (i) it is known that Mutoe belongs to the Moribane Forest Reserve<sup>22</sup>; (ii) this is an area with forest fragments of restricted/prohibited exploitation<sup>23</sup> in addition to the knowledge that the communities have that; (iii) it is an area that belongs to a National Park (CNP) with rules on the forest management of its resources<sup>24</sup>. Another considerable proportion of households (16.7%) assume that, in addition to knowing items i, ii, and iii previously referenced, they also know that, (iv) they have rights within the scope of NRMCM<sup>25</sup> and that; (v) they have duties as a resident of the Chimanimani National Park buffer zone<sup>26</sup>. Only 8.3% constitute the fraction of households that know all the items previously referenced, except (iv) as illustrated in **Figure 5**.

<sup>19</sup> Participated occasionally – this is represented by the number 2 in the “frequency of participation” section of the chart

<sup>20</sup> Never participated - this is represented by the number 2 in the “frequency of participation” section of the chart

<sup>21</sup> Always participated - this is represented by the number 1 in the “frequency of participation” section of the chart

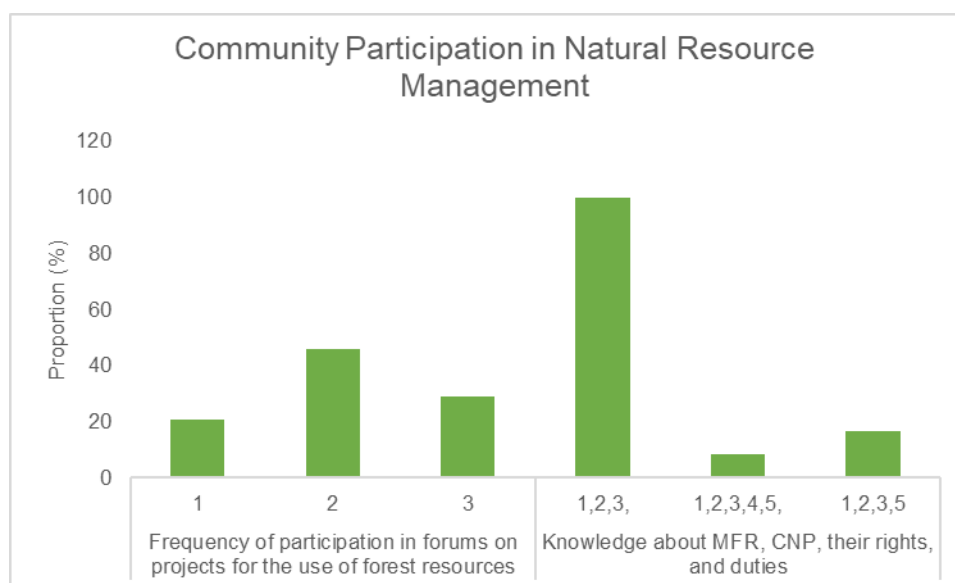
<sup>22</sup> Mutoe belongs to the Moribane Forest Reserve - This is represented by the number 1 in the “knowledge about MFR and CNP” section of the chart

<sup>23</sup> Knowledge about the existence of prohibited forests from exploration in the MFR - this is represented by the number 2 in the “knowledge about MFR and CNP” section of the chart

<sup>24</sup> Knowledge about the existence of forest management rules in the PNC and its Buffer Zone - this is represented by the number 3 in the “knowledge about MFR and CNP” section of the chart

<sup>25</sup> Existence of rights under the NRMCM - this is represented by the number 4 in the “knowledge about MFR and CNP” section of the chart

<sup>26</sup> Existence of duties as a resident of the CNP and its buffer zone - this is represented by the number 5 in the “knowledge about MFR and CNP” section of the chart



**Figure 5.** Frequency of participation in consultations on projects for the use of forest resources.

### 3.2.1. Management of the Chimanimani National Park

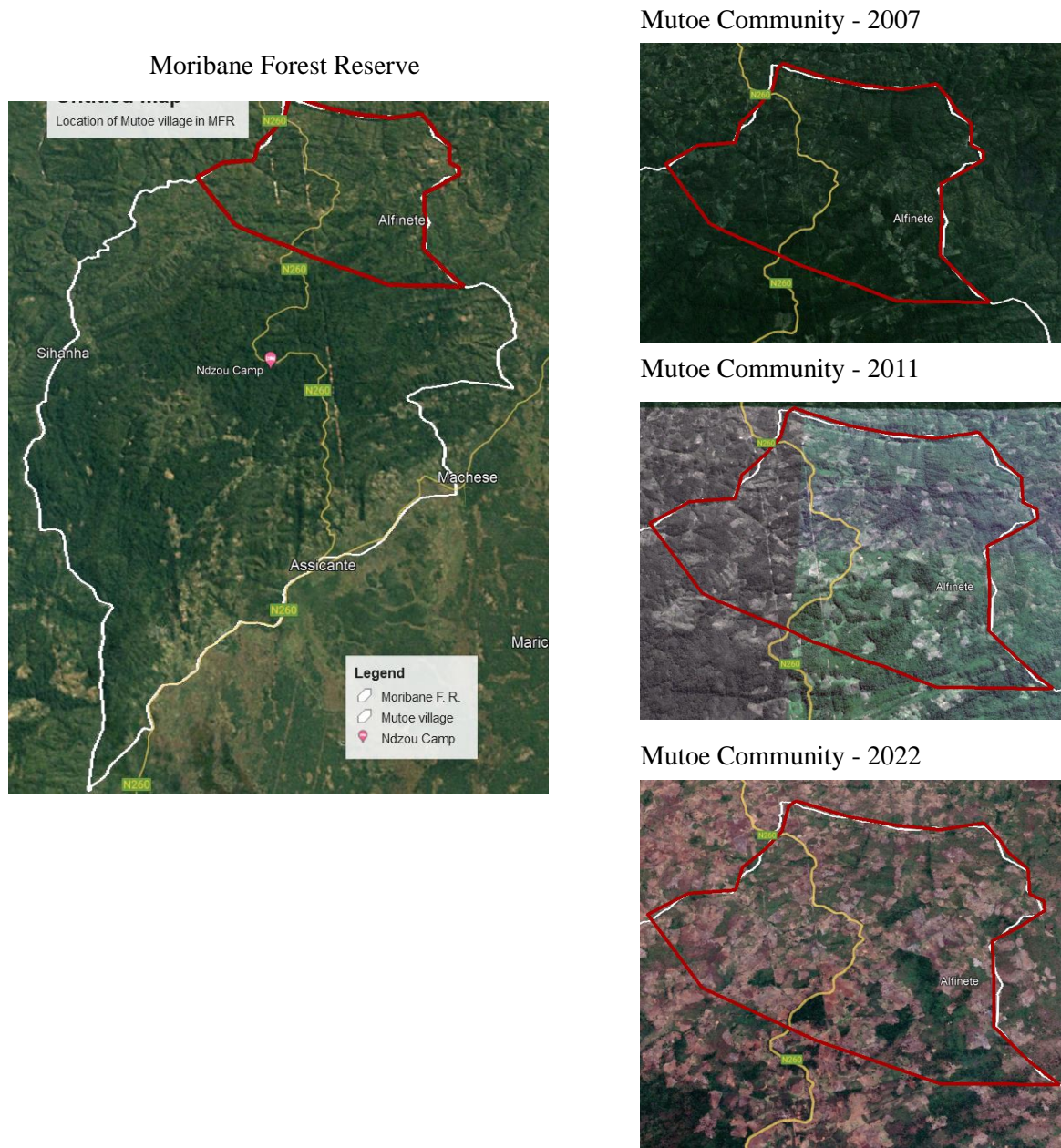
Still, within the scope of the interviews, it was verified that the CNP, the entity responsible for managing the MFR where the Mutoe community belongs, in light of the Management Plan, promotes and executes the activities contained in this plan to (i) to combat the main threats affecting the persistence of the region's biodiversity and, (ii) to promote community development. See **table 2** below:

**Table 2.** Understanding of the Management of the Chimanimani National Park about the management of Natural Resources.

Order	Aspects raised	Answers
1	Main activities developed at MFR	To preserve biodiversity To ensure ecological balance To promote the tourist attraction To promote community development in BZ
2	Rights of Buffer zone (BZ) communities	To benefit from the resources within the limits of the law
3	The existence of the MFR Natural Resources Management Committee (NRMC)	Exist
4	Level of community participation in MFR's NRMC	Satisfactory
5	NRMC management model	Participative
6	Participation of communities in decision-making processes	Often, only leaders participate
7	Incentive CNP offers to communities	Promotion of the right to use and benefit from land (DUAT) Free collection of firewood Collection of construction material
8	Frequency of community training/awareness on sustainability	Quarterly
9	Enforcement mechanism	Patrols Participatory community surveillance

### 3.3. Description of changes in vegetation cover that occurred in the community between 2007 and 2022

In 2007, the images show a predominance of dense vegetation with an estimated coverage percentage of almost 100% of the study region (Mutoe). In 2011, this scenario changed, with a considerable reduction in vegetation coverage being observed, with greater incidence in the northern and northwestern parts of Mutoe. The scenario becomes critical in 2022, with estimated losses of almost 80% of vegetation coverage compared to the reference year (2007), as illustrated in **Figure 6**.



**Figure 6.** Changes in land use and cover in the Mutoe community within the Moribane Forest Reserve, Chimanimani National Park Buffer Zone (2007 – 2022).

Source: Recreated from Google Earth. True color satellite image; dark green indicates dense vegetation, light green sparse vegetation, and gray rocky outcrops with or without vegetation). Dark green spots (dense vegetation) aiming to capture forest fragments were considered.

## 4. Discussion

### 4.1. Identification of socio-economic aspects related to family subsistence

The Mutoe community is the most populous among the four communities in the Moribane Forest Reserve located along the National Road 216 corridor, with around 200 households. These families are mostly native (75%) of the Sussundenga district and mostly made up of more than 6 members (20%). A considerable part of this population is illiterate (27.3%) and/or has a low level of education that varies between primary and secondary levels (50%). Almost all live in precariously constructed houses built on stakes and straw (66.7%), except some families living in improved houses built on burnt bricks (8.3%). Almost everyone (87.5) consumes water acquired directly from the river and the main sources of lighting are flashlights and cell phones (100%) charged through solar panels (**Figure 2**). The MP states that the communities located in the park, due to the social conditions they present, have low levels of education and limitations in conceiving and undertaking projects that aim to explore the opportunities for tourist services that will arise with the development of tourism<sup>[30]</sup>.

The main economic activity among the communities in the CNP BZ is agriculture, in which corn, mapira, banana, and sesame are the main crops<sup>[11]</sup>. According to those interviewed, all families have agriculture, beekeeping, banana cultivation, and livestock farming as their main subsistence activity (**Figure 3**). They grow a variety of crops, including corn, sorghum, orchards, and bananas. Occasionally, they also grow sesame, often with the support of the *Moz Bio project*. Honey and bananas are the main products sold, but sometimes surplus cereals and occasionally livestock products are also sold by some families. These subsistence activities ensure that 79.2% of households have an average of three meals a day, with the remaining proportion (20.8) having two.

However, given the difficulties in large-scale production and the difficulty of means of production in times of drought, especially, almost everyone faces periods of food insecurity. Typically, the months of food insecurity have been July to February (33.3%), June to February (25.5%), and August and September to February with 28.8% respectively. These periods highlight the weak production that is not capable of supporting the food needs of families from one harvest to the next. Alternatively, families survive through the sale and consumption of bananas and, in some families, honey. They also alternatively consume other forest products such as mushrooms and wild fruits. The MP points to beekeeping as a source of income that encourages ecosystem conservation because communities avoid burning and deforestation in the areas where the hives are located<sup>[30]</sup>. In terms of income per product sold/year, it was found that beekeeping and banana sales were the most profitable activities in the majority of families (62.5%) with a minimum income of 8000.00 metcais (equivalent to 1265 US dollars) per family per year.

Firewood is used to prepare food, heat water, to prepare alcoholic beverages, among other uses, 87.5% of households assume that it is extracted mainly from farms through the collection of debris resulting from the cleaning of fields and sometimes, in areas of and fallow through the felling of bushes in the process of regeneration. Regarding agricultural practices, an activity permitted in Buffer zone (BZ), it was found that a considerable part of the families (70.8%) assume that they use the hoe, the ax, and other instruments to clean the fields, with fire being an instrument that they know about. its destructive power when not controlled, which is why only 20% of those interviewed admitted that they use it but under extreme caution. Even though in the ZP, according to the MP, the use of fire to clean fields is an expressly prohibited activity<sup>[30]</sup>.

Almost all families (87.55) have basic knowledge about the importance of the forest, namely, (i) the notion that the forest is a habitat for fauna; (ii) constitutes an alternative source of food and healing for local communities through timber and non-timber forest products and; (iii) It is the main source of energy for rural

communities. Families assumed that this knowledge had been acquired through awareness campaigns carried out by inspectors and other mobilization teams linked to the MFR, the CNP, and the district Economic Activities Services. Within the scope of these campaigns, a considerable number of families (66.7%) also admit that they have become aware of some limitations in accessing certain reserve resources in certain areas through legal coverage (**Figure 4**). The families also assume that they know the limitations of resource exploitation in certain areas of the reserves as they constitute sacred areas of the communities. Therefore, they assume their participation in collaboration through practices that do not conflict with their conservation and veneration. According to CEAGRE<sup>[31]</sup>, the BZ is where the majority of the human population resides and where they carry out their subsistence activities such as agriculture, fishing, commerce, and various other economic, social, and cultural activities.

#### **4.2. Participation of the Mutoe community in the management and use of forest resources**

Only 20.8% of those interviewed admitted that they had always participated in forums that focused on projects for the use of forest resources at the reserve level. This group includes community leaders and some heads of households with some type of administrative responsibility at the community level. It was found that the majority of those interviewed, corresponding to close to half (45.8%), admitted that they had participated on a few occasions in forums whose theme would have been projected for the use of forest resources in the Moribane Forest Reserve. Something worrying in this regard is the proportion of interviewees who would have assumed that they never participated. This group represents 29.2% and may represent a threat to conservation objectives as members and residents of the community within the reserve. This fact can be considered serious, especially if local community leaders are not playing their role as a replica in the dissemination of information mainly related to the promotion of positive awareness about biodiversity conservation.

It is important to emphasize that a community program, especially in the BZ of a conservation area, has two main objectives: (i) to contribute to improving the living conditions of the population residing in the park and buffer zone sustainably, and (i) to improve park governance by promoting the participation and collaboration of various actors in management, including local communities<sup>[32]</sup>. The implementation of this program will contribute to the achievement of the strategic objectives of community and economic-financial development of the ANAC Strategic Plan 2015 – 2024<sup>[30]</sup>. About the level of knowledge that households have regarding the MFR, the CNP, their rights and duties as residents within it, it was found that everyone (100%) knows that, (i) Mutoe belongs to the MFR; (ii) they also know that there are forests prohibited from exploiting resources in the community in which they live and that; (iii) a national park has natural resource management rules in light of legislation.

However, the proportion of them that respect the rights and duties and are committed is only 8.3%, which in a certain way may represent a threat to conservation objectives as illustrated in **Figure 5**. Regarding community rights, according to<sup>[32]</sup>, the low participation in sharing benefits arising from biodiversity conservation, combined with restrictions on the practice of agriculture and the use of natural resources and human-wildlife conflicts, creates an environment conducive to the development of negative attitudes towards communities facing conservation and conflict between them and the park administration. The sharing of diverse benefits (for example, those derived from ecotourism) serves as an incentive and stimulates the active participation of communities in conservation as they feel the positive impact of biodiversity on their lives<sup>[11]</sup>.

Among the main activities carried out at MFR are the preservation of biodiversity to ensure ecological balance; the promotion of tourist attraction and community development in the BZ. It was also learned that

benefiting from resources within the limits of the law constitutes a fundamental right granted to communities residing in the BZ, which is why a Natural Resources Management Committee (NRMC) was created.

It was also made known by the CNP management sector that this committee is based on a participatory management model whose performance was described as being satisfactory up to that time (2023). The CNP management also made it clear that it gives incentives to the ZP communities through its partners, where it assigns Land Use and Benefit Rights (DUAT) to the communities, the collection of wood fuel and material for the construction of housing at the local level is authorized.

It is necessary to highlight the restrictive measures for extraction in some places, especially sacred ones, ending up being something of mutual benefit, communities that preserve culture and the conservation sector.

Other activities with incentives include (i) beekeeping by supplying improved hives made by the Micaia Foundation, which is subsequently responsible for purchasing the product for refining and resale, and; (ii) sesame production, which is supported by the provision of seeds by Moz Bio, which after production is responsible for purchasing the product. From the CNP MP, it is known that the sustainable exploitation of non-timber forest products (NTFPs) by communities (e.g. beekeeping, grass, medicinal plants, wild fruits, tubers, etc.), subsistence hunting and fishing (using permitted techniques by Law) constitute allowed activities<sup>[30]</sup>. It is important to note that the effectiveness of protected area management depends on the resources allocated to the implementation of management operations. According to the Management Plan (MP), since its creation, the CNP has not produced sufficient revenue to guarantee its financial sustainability due to the low level of tourism development (tourist arrivals, tourist activities, services, and concession fees). For this reason, the CNP depends on the state budget and donor projects to carry out basic management operations<sup>[30]</sup>.

It was also learned that the frequency of training and/or community awareness activities on the topic of environmental sustainability is quarterly and the mechanism for inspection activities consists of patrols and surveillance involving the participation of community members. It is known that the creation and strengthening of Base Community Organizations (OCBs) in the form of Natural Resources Management Committee (NRMC) and/or associations must be a priority in the management of the CNP so that they can be active partners in raising awareness and supervision for the orderly and sustainable use of natural resources in the buffer zone and thus prevent the proliferation of these threats in the central zone<sup>[32]</sup>.

#### **4.3. Description of changes in vegetation cover that occurred in the community between 2007 and 2022**

Between 2007 and 2022, progressive changes in land cover were observed, characterized by an increase in deforestation and with a greater incidence exactly in the study region, the northern part of the MFR (**Figure 6**).

From **Figure 6**, it can be seen that in the reference year (2007), the area was a dense forest, almost free of gray or brownish colors that would somehow represent exposed soil or rocks. This scenario highlights minimal human disturbance in the forest fragments of the Mutoe community during this period. This fact can be justified by the low demographic density of the area at that time and agricultural activity probably did not yet represent one of the main factors in deforestation due to the small number of practitioners whose purpose was just subsistence. At this time, the Chimoio-Sussundenga corridor was probably not yet attractive for immigrants who might be interested in living and developing activities in Mutoe.

In 2011, considerable changes were observed in the vegetation cover evidenced by numerous lightened fragments meaning complete elimination and/or reduction in tree density in these points. These activities may have taken place due to several factors, including:

- New settlements attracted by the asphaltting project of the Chimoio – Mossurize section, which was expected to boost the economy through the ease of flow of various products, with emphasis on bananas potentially grown in the MFR community;
- Result of population growth within the reserve communities and the need to occupy new areas for residence and agricultural practice and;
- Resettlement of displaced people from the communities of Mpunga, Magaraba, Sanguena, and Mucuawaio due to the increased severity of restriction measures in areas with a predominance of evergreen forest, strategically important locations for the movement of elephants (*Loxodonta africana*) in the MFR.

According to the MP, the construction of National Road No. 260 which crosses the Moribane Forest Reserve stimulated the proliferation of the population and the opening of new farms to increase commercial production, especially bananas and corn, as it improved the flow of agricultural products to the main markets in large cities. On the other hand, the expansion of housing areas is caused by the intrinsic growth of the human population and the formation of new families.

In 2022, there will be changes with signs of a severe deforestation scenario in the Mutoe community. According to<sup>[32]</sup>, banana production has expanded rapidly in the Mpunga community over the last 20 years. The increase in population resulted in a change in land use, through the expansion of agricultural and housing areas. This fact clearly and seriously shows the impact of pressure on forest resources in the last 10 years, characterized by the indiscriminate felling of trees to probably give way to activities of agriculture and/or ensure provisioning services.

The dominance of clearings about vegetated areas is observed, highlighting a scenario of events related to demographic dynamics characterized by an increase in settlements with a consequent increase in areas for the practice of subsistence activities, with emphasis on banana cultivation. This scenario foresees a tragic fate for the objectives of conserving biodiversity in the reserve since, if this trend prevails, the settlements will be projected in a north-south direction, reaching the most sensitive areas of the reserve, with emphasis on the Mpunga community, where the largest number of sacred areas. This area is the most strategic in the reserve, especially for elephant viewing.

According to Timberlake et al.<sup>[11]</sup>, in the BZ, activities that are essential for improving the living conditions of local communities are permitted, as long as they do not compromise the conservation of biodiversity and maintenance of ecosystem services. However, the main threats to the values and general objectives of CNP management include:

- Deforestation caused by the expansion of agriculture and housing areas;
- Expansion of the exotic and invasive shrub species *Vernonanthura phosporica*;
- Climate change;
- Uncontrolled fires and;
- Poaching.

Regarding invasive species, according to Timberlake et al.<sup>[11]</sup>, this is native to Brazil and was introduced in Sussundenga in the early 1990s by an international NGO with the aim of promoting the development of beekeeping. The species is expanding widely in areas disturbed or deforested by agriculture or fires, both in the buffer zone and in the central zone. This species suppresses the regeneration of native flora species, becoming dominant.

Therefore, looking at the current scenario, it becomes increasingly important to involve local communities in conservation activities through programs that encourage them to reduce pressure on resources, such as the *Micaia Foundation projects* through *Nzou Camp* in the community of Mpunga. According to [www.micaia.org](http://www.micaia.org), the *MICAIA Foundation* is an entirely not-for-profit entity and it is an inclusive part of a hybrid organization called *Eco-MICAIA Ltd*. This organization develops opportunities for producers (farmers) and communities to participate in inclusive businesses i.e. commercial enterprises in which workers, producers, and/or communities as a whole can be included as suppliers, managers, and if possible, as owners. *MICAIA's* belief is that if sustained livelihood opportunities are to be created, it is necessary to shift at some point from subsidy (grants and donations) to investment. *Eco-MICAIA Ltd* provides three types of service: (i) they carry out feasibility studies, market research, etc and in some cases work with producers and communities on the development of business plans. (ii) they facilitate access to finance and; (iii) they look for opportunities to create partnerships between communities/producers and private sector companies or entrepreneurs.

Projects of a diverse nature in areas of agriculture and livestock farming that promote increased family income are also suggested and recommended for implementation outside the MFR. In return, teams can be formed at the level of beneficiaries of MFR incentives with the mission of participating in reforestation programs and management of the regeneration of degraded areas to return the ecosystem of the Mutoe region and beyond, the destroyed structure and composition by anthropogenic action over time. It is important to note that, according to the Management Plan in force, the CNP's management actions must be based on effective communication and coordination with the district and provincial Government and with the justice administration bodies so that these institutions can take ownership of these and consider them as part of the implementation process of the Economic and Social Plan and the Government's Five-Year Program. This would be one of the strategies aimed at making the connection between conservation actions belonging to the state and grassroots organizations more robust. As a limitation, this research does not accurately show the proportion of losses in vegetation cover over the period under analysis, which opens up opportunities for research in this regard in the area in question. The results can be used to support decision-making on the type of intervention that can be made in the reserve. This intervention can be done either through measures that improve local practices that cause losses of forest over as well as through incentives that promote their participation in the management of natural resources to ensure that they contribute increasingly and better to the local environment.

## 5. Conclusion

We conclude that:

- The majority of the population of Mutoe village lives in precarious conditions and their main subsistence base is slash-and-burn agriculture. This activity has been cyclically affected by drought, resulting in a reduction in cereal production, causing the population to face long periods of food insecurity. This population has a low level of education, with limitations in conceiving and undertaking projects that aim to explore opportunities for local tourist services. The main activities also include the production of honey and bananas;
- Community participation in decision-making forums for resource management is weak, consequently representing a threat to conservation objectives combined with the fact that a considerable part of them is unaware of their rights and duties about the use of forest resources;



- Between 2007 and 2022 there was a considerable reduction in vegetation cover in almost the entire area of the Moribane Forest Reserve, with greater impact on the community of Mutoe, mainly due to agricultural activities and the establishment of new human settlements.

## **Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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