frontiers | Frontiers in Forests and Global Change

ORIGINAL RESEARCH
published: 13 April 2022
doi: 10.3389/ffgc.2022.840717

Impact of Conservation Policies on Households' Deforestation Decisions in Protected and Open-Access Forests: Cases of Moribane Forest Reserve and Serra Chôa, Mozambique

Jadwiga Massinga[1], Sá Nogueira Lisboa[1,2], Pekka Virtanen[3] and Almeida Sitoe[1]*

[1] Faculty of Agriculture and Forest Engineering, Eduardo Mondlane University, Maputo, Mozambique, [2] N'Lab, Nitidae, Agostinho Neto Avenue, Maputo, Mozambique, [3] Department of Social Sciences and Philosophy, University of Jyväskylä, Jyväskylä, Finland

OPEN ACCESS

Edited by:
Jiajia Liu,
Fudan University, China

Reviewed by:
Yan Gao,
Universidad Nacional Autonoma de Mexico, Mexico
Alam Zeb,
Shaheed Benazir Bhutto University, Pakistan
Marina Mazón,
National University of Loja, Ecuador

***Correspondence:**
Jadwiga Massinga
jadwiga.massinga@gmail.com

Specialty section:
This article was submitted to Forest Disturbance, a section of the journal Frontiers in Forests and Global Change

Received: *21 December 2021*
Accepted: *24 February 2022*
Published: *13 April 2022*

Citation:
Massinga J, Lisboa SN, Virtanen P and Sitoe A (2022) Impact of Conservation Policies on Households' Deforestation Decisions in Protected and Open-Access Forests: Cases of Moribane Forest Reserve and Serra Chôa, Mozambique. Front. For. Glob. Change 5:840717. doi: 10.3389/ffgc.2022.840717

Tropical deforestation is considered a global priority due to its environmental, social, and economic impacts at international, national, and household levels. Conservation policies constitute one of the pathways to reverse this scenario. This paper examines the influence of forest protection measures on local communities' livelihood decisions regarding forest clearing. It compares deforestation, access to forest resources, and households' strategies in protected and open-access forests: the Moribane Forest Reserve (MFR) and Serra Chôa (SCH), two environmentally sensitive areas with different conservation statuses in Manica Province, central Mozambique. Socioeconomic data were collected from September 2019 to August 2020 in 149 households in MFR and 144 households in SCH. The data were cross-examined with spatial information on deforestation from 2000 to 2020. We found that conservation status impacted household strategies, leading to less income source diversification and limited commercialization of forest products. In both areas, most respondents declared unlimited access to forest resources (89.9% for MFR and 68.8% for SCH), and the remaining proportion of respondents pointed out conservation, private forest, distance, and wildlife conflict as reasons for limited access. Shifting agriculture is the unique income source for 75.2% of the families in MFR and 28.4% in SCH. Most households in SCH diversify their income by combining shifting agriculture and livestock (68.75% against 24.8% in MFR). About 97% of the sampled households in MFR cleared forest for agriculture during the period 2000–2020, while 55.6% of the households cleared the forest in SCH during the same period. In MFR, non-timber forest products are mainly for subsistence use, except honey, which is sold by 52.2% of families. In SCH, commercialization of non-timber forest products is more diverse, with 11.1% of families selling honey, bush meat (5.5%), charcoal (3.4%), medicinal plants (2%), wood (1.3%), poles (11.1%), and firewood (12.5%). We conclude that the current conservation policies have little impact on household decisions to protect the forest, but they influence income diversification, leading to more dependency on agriculture and livestock.

Keywords: livelihoods, forest access, NTFP, protected area, logit model

INTRODUCTION

Deforestation is a common problem in tropical countries like Mozambique, increasing their environmental sensitiveness and climate change vulnerability and hampering the livelihoods of rural communities (FAO and UNEP, 2020). National inventories of forest resources conducted in Mozambique show an increasing tendency to reduce forest areas due to human activity (MITADER, 2018b). Different reasons are pointed as drivers—mainly commercial and shifting agriculture, firewood and charcoal, urbanization, mining, logging, and livestock (Sitoe et al., 2016). The central and northern parts of Mozambique experience more forest area decrease, with Nampula, Zambezia, and Manica provinces as the most affected (MITADER, 2018a). In the Manica Province, deforestation rates (0.7%) are higher than average for the whole country (0.6%), showing a clear tendency to increase, especially in areas close to urban centers (Ryan et al., 2014; MITADER, 2018a).

Reduction in forest product availability and decline in ecosystem service provision are solid reasons to change the management approach of the remaining forested areas through better control of forest resources, an increase of forested areas, and the revival or foundation of new protected areas (FAO and UNEP, 2020). The forest transition theory points conservation policies and legislation as one of the paths to achieve the change in forest cover from loss to gain (Ashraf et al., 2016; Park and Youn, 2016; Youn et al., 2017). Forest conservation in Mozambique is addressed in a diversity of legislative documents—policies, laws, development projects, and regulations—but also at an informal customary level where a traditional leader is responsible for standards compliance within the community (Sheila de Menezes Advogados, 2017; Wamir et al., 2017). At the customary level, conservation is done mainly by accepting natural resource access restrictions and limited use of specific plants and animals or sacred places (Matos et al., 2021).

At a level regulated by the state, the main goal is to achieve sustainable development through the rational use of natural resources and inclusion of local communities in the management process (Givá and Raitio, 2017). Conservation is an integral element of community development, where the rural population should actively participate in forest management, which implies the possibility to conciliate the conservation agenda with human well-being (Sitoe and Guedes, 2015). However, community participation is insignificant and often limited to managing benefits received from commercial licensing (World Bank, 2018). In the conservation areas, core objectives are the preservation of ecosystems and species without resource extraction, allowing only the indirect use of natural resources (Matos et al., 2021). Up to now, Mozambique has allocated 23% of its territory for conservation purposes; yet, the protection endeavors are diminished by human settlements within and around conservation areas (Rylance, 2016).

Access to resources is state-controlled by specific conditions, like the tenure system, which allows the coexistence of two types of tenure—ensured by state laws and by customary rules (Chiziane et al., 2015). The state-based tenure system does not allow private ownership of land, forest, or other natural resources within protected areas. However, the absence of a title deed does not damage the right to use land and resources by singular people and communities (Balas et al., 2021). In open-access areas, the management is centered on licensing, reforestation, establishment of forest plantations and community forests, and the promotion of more environmentally friendly agricultural practices, like conservation agriculture or agroforestry (Bleyer et al., 2016; Nube et al., 2016). In Mozambique, more than 80% of the population relies on ecosystem services provided by natural resources, and shifting agriculture is a popular and common practice assumed as the most contributing driver of deforestation (Sitoe et al., 2016). However, shifting agriculture can also play an essential role as a buffer allowing forest regeneration in opposition to other land uses like intensive agriculture, perennial plantations of cash crops, or forest plantations (Dewi et al., 2017).

Most existing studies about deforestation in Mozambique analyze small-scale agriculture's role in deforestation, mainly at the regional level, with little attention to direct deforestation agents and their role in forest conservation (Jansen et al., 2008; Ryan et al., 2014; Sitoe et al., 2016). The regional level brings us the general picture of deforestation trends and helps in understanding the different forces that impact the forest. It is valuable for the overall picture but less useful for perceiving the local forces behind the phenomenon. Deforestation starts at the local level, with individual households making the decision to clear or not to clear forests based on a diversity of factors related to the livelihood framework (Ojeda Luna et al., 2020). Perception about the reasons behind households' decision is crucial if we want to design and implement conservation policies that will make a difference at a local level. This paper examines the influence of conservation policies on local communities' livelihood decisions regarding forest clearing in areas with and without conservation status. This study centers on the following questions: (i) What are the households' perceptions regarding access to forest resources? (ii) Do livelihood strategies differ between protected and open-access areas?, And (iii) does diversification of livelihood strategies reduce deforestation?

MATERIALS AND METHODS

Study Area Selection and Description

The study areas are the Moribane Forest Reserve (MFR) in Sussundenga District and Serra Chôa (SCH) in Barue District, Manica Province (**Figure 1**). We selected the study areas, taking into account the existence of transitional forest in environmentally sensitive places with human presence, but with different land tenure systems—protected and open access. The spatial extent is limited to two mountainous places in Manica Province, MFR and SCH, recognized as critical habitats under the International Finance Corporation criteria due to their importance to biodiversity, the existence of endemic species, the occurrence of key evolutionary processes, and high scientific value (Virtanen, 2002; Sitoe et al., 2015). The MFR is considered the most extensive and best-preserved lowland rainforest in Mozambique (Müller et al., 2005). Its topography

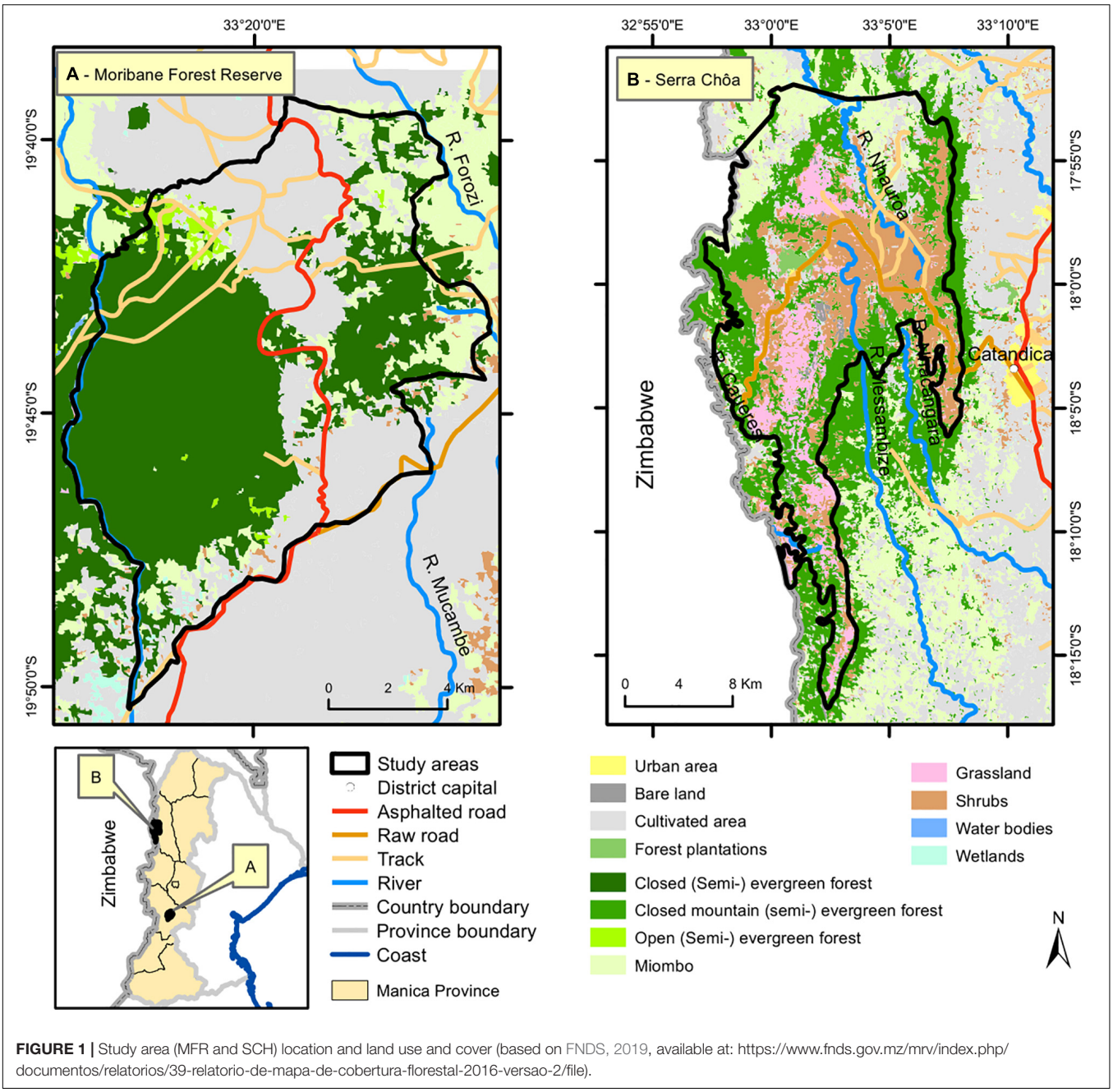

FIGURE 1 | Study area (MFR and SCH) location and land use and cover (based on FNDS, 2019, available at: https://www.fnds.gov.mz/mrv/index.php/documentos/relatorios/39-relatorio-de-mapa-de-cobertura-florestal-2016-versao-2/file).

is irregular—varying from 400 to 550 m above sea level. The non-protected area, SCH, is situated in highlands above 1,200 m (Cizek, 2009). Wooded or open grasslands dominate the SCH vegetation at the central and southern plateau, miombo dominates in the northern area, and mountainous evergreen forests dominate in steeper slopes (Mussanhane et al., 2000).

Moribane Forest Reserve is a protected area that was created in 1957 for wood production and since 2010 has been a part of the Chimanimani National Park (CNP) buffer zone (ANAC, 2021). As legislation states, the national park has the function to protect, conserve, and manage the biodiversity (Governo de Moçambique, 2014). Human presence is allowed under specific conditions set by the management plan and should not threaten the biodiversity; only indirect use of natural resources is allowed. Conservation legislation does not recognize the forest reserve as a protected area but defines objectives of a buffer zone (MITADER, 2019). According to current legislation, economic activities are allowed in the buffer zone, although priority is given to activities in line with conservation purposes like protection of water courses, landscape maintenance, and low urbanization (Governo de Moçambique, 2014). The current CNP management plan (ANAC, 2021) defines the extraction of non-timber forest products and timber in the buffer zone as only allowed for subsistence. The buffer zone of CNP is larger than the core

protected area, so the modifications in land use and increase of human presence will probably negatively impact the park (Timberlake et al., 2016).

In MFR, the population lives mostly along the N260 asphalted road and in 2017 was estimated at around 2,400 inhabitants. In SCH, human settlements tend to occur in the central and western parts, and in 2017, the population was estimated at approximately 1,800 inhabitants. In 2019, it was estimated that 479 households are in MFR, while in Serra there are 343 households (J. Matias, personal communication, September 13, 2019). SCH, in general, has a low level of transport infrastructure, with one feeder road connecting Catandica and Chôa-Sede and a few tracks connecting communities. In both areas, population density is low (15 inhabitants/km^2 at the MFR and 5 inhabitants/km^2 at SCH), which is considerably lower than the province average, calculated for 2017 at 34 inhabitants/km^2. The population density in the study areas is also lower than that in the respective districts—Sussundenga has 24 people/km^2 and Barue 45 people/km^2 (INE, 2018). Although the density is low, there are areas with relatively dense settlement because people tend to live close to each other and to roads, leaving vast areas uninhabited.

The main economic activity for both sites is agriculture for subsistence and cash. Commercial agriculture is developed mainly to produce macadamia and potato in SCH and banana and sesame in MFR. There is no tourism activity in SCH. In contrast, MFR has the community association Kubatana Moribane, in cooperation with the NGO Eco-MICAIA, which runs the Ndzou Camp lodge (Dondeyne et al., 2012). Nevertheless, a few commercial activities are developed in both areas.

Household Survey

The survey was conducted in four communities in MFR (Mucuawaio, M'Punga Centro, Mutoe, and Magaraba) and the same number in SCH (Muswipa, Chôa-Sede, Doro, and Nhaterere). The total number of households surveyed was 293, with 149 in MFR and 144 in SCH. The sample size calculation was done separately for each site to ensure spatial coverage and representative sampling. Following this, the number of households to interview for each community was calculated based on the proportion of households living in the settlement to the total number of household in the study area.

TABLE 1 | Summary of variables used in the logit model to predict household forest clearing decisions at MFR and SCH.

Variable	Unit/measure	Rationale	Expected sign
Human capital			
Respondent age	years	Younger people have more need to cut forests (Garekae et al., 2017)	−
Respondent gender	Gender (1: female, 2: male)	Women are more dependent on forest resource gathering while men clear forest for agriculture (Sunderland et al., 2014)	+
Education level of respondent	Level (1: not literate, 2: literacy, 3: primary school, 4: secondary school)	Higher education level increases the opportunity for off-farm jobs (Ullah et al., 2020)	−
Number of household members aged 15+	people	Increased number of adults augment possibility to clear forest (Basnyat, 2009)	+
Physical capital			
Size of agriculture plot	ha	Agricultural activity increases the need for new areas (Babigumira et al., 2014)	+
Distance to the nearest road	km	Better connectivity creates trade opportunities, motivating production increase and clearing forest for agricultural use (Charlery et al., 2016)	−
Trading place	Scale (0: not selling, 1: outside study areas, 2: within the study areas, 3: at home)	Better trade opportunities motivate augmentation of agricultural land (Babigumira et al., 2014)	+
Social capital			
Conservation limitations in access to forest	0/1	Limitations linked to conservation reducing deforestation (Wade et al., 2020)	−
Natural capital			
Distance to a forest edge	km	People tend to cultivate near their houses, so distant forests will be less likely cleared (Babigumira et al., 2014)	−
Financial capital			
Household income intervals	Scale (1) $\leq$ 14.0; (2) 14.0–28.0; (3) 28.1–70.0; (4) 70.1–140.2; (5) 140.3–210.4; (6) > 210.4 €/month?	Increased income can be related to augmentation of agricultural production (Babigumira et al., 2014)	+
Livelihood strategies			
On-farm strategies	Sum (staple food, vegetables, cash crops, poultry, livestock, fruit)	More dependency on farm products increases the need for agricultural areas and increases forest clearing (Babigumira et al., 2014)	+
Off-farm strategies	Sum (odd jobs, wages, small business, fishing)	More off-farm job opportunities reduce dependency on forest resources (Miller et al., 2021)	−
Forest-based strategies	Sum (medicinal plants, hunting, honey, poles, firewood, timber, charcoal)	Relying on forest products increases deforestation (MacKenzie et al., 2017)	+

The data collection occurred in two phases—in September and October 2019 in MFR and in August and September 2020 in SCH. Data were collected by two researchers with local guides who were proficient in Portuguese and the local language. Although the questionnaire was in Portuguese, the interviews were in the local languages (ChiNdau and ChiManica). In addition to each questionnaire, there was a record of the geographic location and delimitation of the area belonging to the household, done by the researchers accompanied by the owner or other adult household member. The respondents were mostly household heads, but, in their absence, we interviewed other adults. Our survey covered questions related to household profile, their economic activities, income, and access to and use of forest resources.

Deforestation Assessment in the Study Areas

In 2017, the Manica Province had 1,781,968 ha forested areas, 27% of the total province area. The deforestation rates for Manica Province were assessed at 0.7% (country rate was 0.6%) from 1990 to 2002 and 1.8% (country rate was 0.8%) for the period 2003–2013 (MITADER, 2018b). The forest conversion occurred mainly from natural vegetation to agriculture (Jansen et al., 2008). Since the 1980s, four forest inventories have been conducted in Mozambique (Malleux, 1980; Saket, 1994; Marzoli, 2007; MITADER, 2018b). The sampling methodology, forest definition, and scale differ, so comparing results to evaluate deforestation in specific places is tricky. To overcome this, Global Forest Change data were used, specifically the global forest cover loss for the period 2000–2020 available in the Google Earth Engine (Hansen et al., 2013). The datasets were based on the analysis of the Landsat image time series, which captured the changes of forest cover at the global level obtained up to the year 2020 on the Google Earth Engine platform. A study by Hansen et al. (2013) set the tree cover for the year 2000 and quantified the forest losses and gains, where forest loss was considered as a complete tree cover canopy removal and forest gains were assumed as the reverse. The tree cover defined for the year 2000 captures vegetation taller than 5 m and records the percentage of the canopy for each cell, varying from 0 to 100. To define areas as forested, we applied a threshold of 30% of tree cover to the Hansen et al. (2013) data. The advantage of this dataset is its consistency and easy access, as well as the possibility to compare data from a long period (Galiatsatos et al., 2020).

The dataset in grid format was clipped to the study areas and downloaded. In ArcGIS version 10.1, the grids were converted into polygon vector data. The grid was converted into a binary raster of values, 1 for forest cover loss and 0 for no forest cover loss, and the area was calculated for the forest cover loss. The next step was to clip data with farmers' plots to find out which households cleared forest.

Data Analysis

We first performed an exploratory data analysis computing the basic descriptive statistics (mean, median, SD) to examine the respondents' and households' characteristics and livelihood strategies and to find similarities and differences between the study areas. The strategies were grouped into three main classes: on-farm, off-farm, and forest-based. Then, the possible multicollinearity was analyzed using the Spearman nonparametric test.

We used a logit regression model to assess the probability to clear the forest by households based on Greene (2002) and the following form:

$$Log\left(\frac{Pi}{1-Pi}\right) = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} \ldots + \beta_n X_{n,i} \quad (1)$$

The logit model is frequently applied for deforestation evaluation looking at different economic, social, and spatial variables in large and local scales (Ojeda Luna et al., 2020; Ullah et al., 2020). The dependent variable is binary and depicts the occurrence or non-occurrence of forest clearing between 2000 and 2020 at the household level (0: absence of forest clearing; 1: occurrence of forest clearing).

The explanatory variables that influence household decisions to clear forests are listed in **Table 1**. Household is considered a basic social unit where decisions are made regarding the production and use of available assets, namely (i) natural, (ii) social, (iii) human, (iv) physical, and (v) financial (DFID, 1999). The availability and quality of assets determine how natural resources are used and their impact on the environment (Wunder et al., 2014). In addition, external factors such as institutions, economic factors, different policies, and cultural factors influence the assets (Yang et al., 2019). We divided the values by root mean square for standardization purposes to run a regression model and better compare the effects of each independent variable (Pir Bavaghar, 2015). The variance inflation factor (VIF) revealed a moderate correlation as the values for independent variables are between 1 and 2. We performed the analysis through RStudio version 1.2.5019 (RStudio Team, 2020).

RESULTS

Forest Cover Changes at the Study Areas

We found that in 2000 the SCH had more significant forest extensions than the MFR, but comparison of the total surface versus forested area showed higher forest occurrence in the protected area, MFR, than in non-protected SCH (**Table 2**). The average annual forest loss from 2000 to 2020 was 276.0 ha/year for MFR and 88.8 ha/year for SCH. In MFR, most deforestation occurred between 2014 and 2017, while in SCH the deforestation was most notable in 2017 (**Figure 2**).

TABLE 2 | Tree canopy cover above 30% in 2000 by study sites MFR and SCH and its percentage to total study areas (based on Hansen et al., 2013).

Study area	Tree cover ≥ 30% (ha)		Tree cover < 30% (ha)		Total area (ha)
	Hectares	% of the total area	Hectares	% of the total area	
MFR	15,842.7	98.2	290.9	1.8	16,133.7
SCH	26,976.5	63.2	15,682.2	36.8	42,658.8

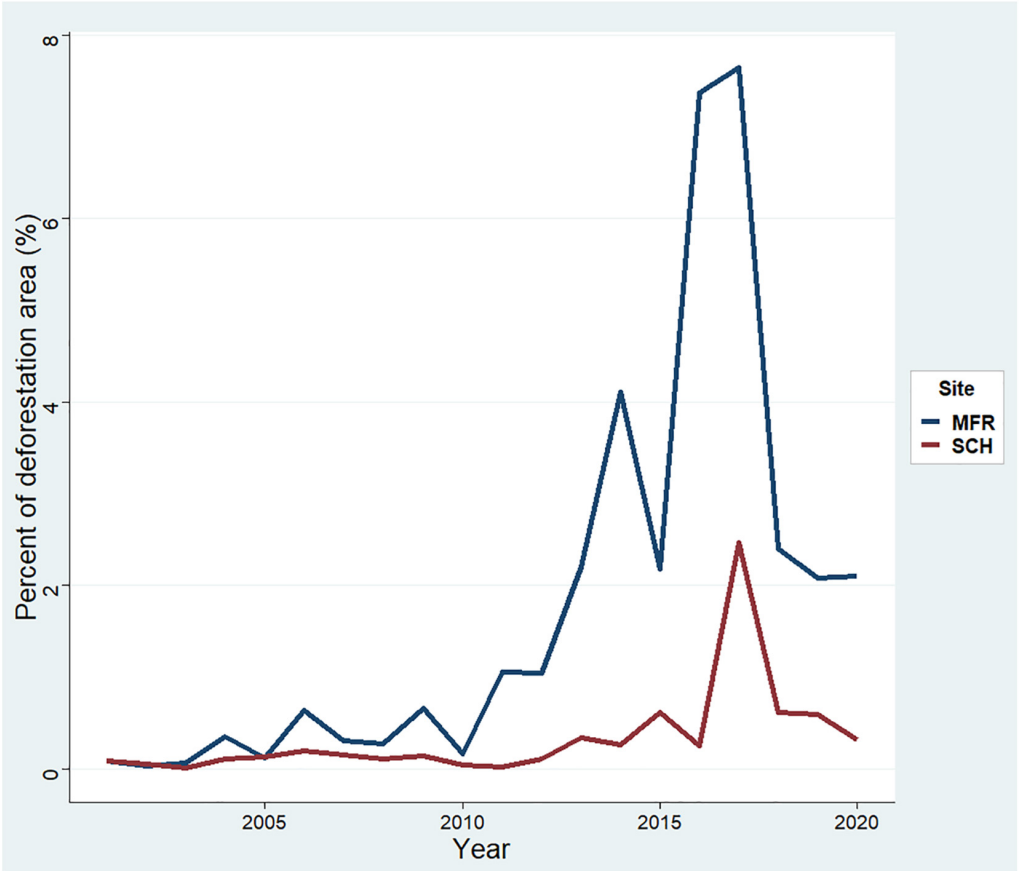

FIGURE 2 | Deforestation percentage per year in MFR and SCH (based on Hansen et al., 2013, available at: https://earthenginepartners.appspot.com/science-2013-global-forest).

Household Demographic Characteristics

In MFR, 41% of the interviewees were women and 59% were men; in SCH, the percentage of women was 35% and men 65%. The average age of respondents was 42.3 years in MFR and 41.7 years in SCH. In general, men are better educated than women, and respondents in SCH are better educated than in MFR, where illiteracy is relatively high and directly related to gender. The highest level attained by most respondents in both areas is primary education. Analyzing the availability of workforce within the household, we found that 70.5% of households in MFR have one to four members who are economically active. The remaining 29.5% of households have five or more adult members. In SCH, the number of households with one to four members is 86.1%, and the remaining 13.9% have five or more adult members (**Table 3**).

Households' Perceptions Regarding Access to Forest Resources

In the study areas, the local leadership plays an important role in forest management. The local leader was pointed out as the person contacted to issue permission by 50.3% of households in MFR and by 61.8% of households in SCH. When asked about any limitations imposed by conservation status or cultural reasons, 89.9% of the MFR respondents and 68.8% of SCH found no restrictions or problems in accessing forest resources (**Figure 3**). There are slight differences between the two areas in reasons behind perception about difficult access to the forest. The ownership of the forested parcels by private citizens is mentioned by 4.2% of households in SCH, which is in accordance to the Land Act that allows citizens in open areas to hold the right to

TABLE 3 | Summary of respondents' demographic profile in study areas MFR and SCH.

Variable	Category	MFR		SCH	
		Male (%)	Female (%)	Male (%)	Female (%)
Age	16–35	25.5	13.4	24.8	15.3
	36–59	25.5	19.5	29.2	12.5
	> 60	8.1	8.1	8.3	6.9
Education level	No education	10.7	25.5	4.2	2.8
	Literacy class	2.0	1.3	0.0	1.4
	Primary school	40.9	13.4	45.1	25.7
	Secondary school	5.4	0.7	16.0	4.9

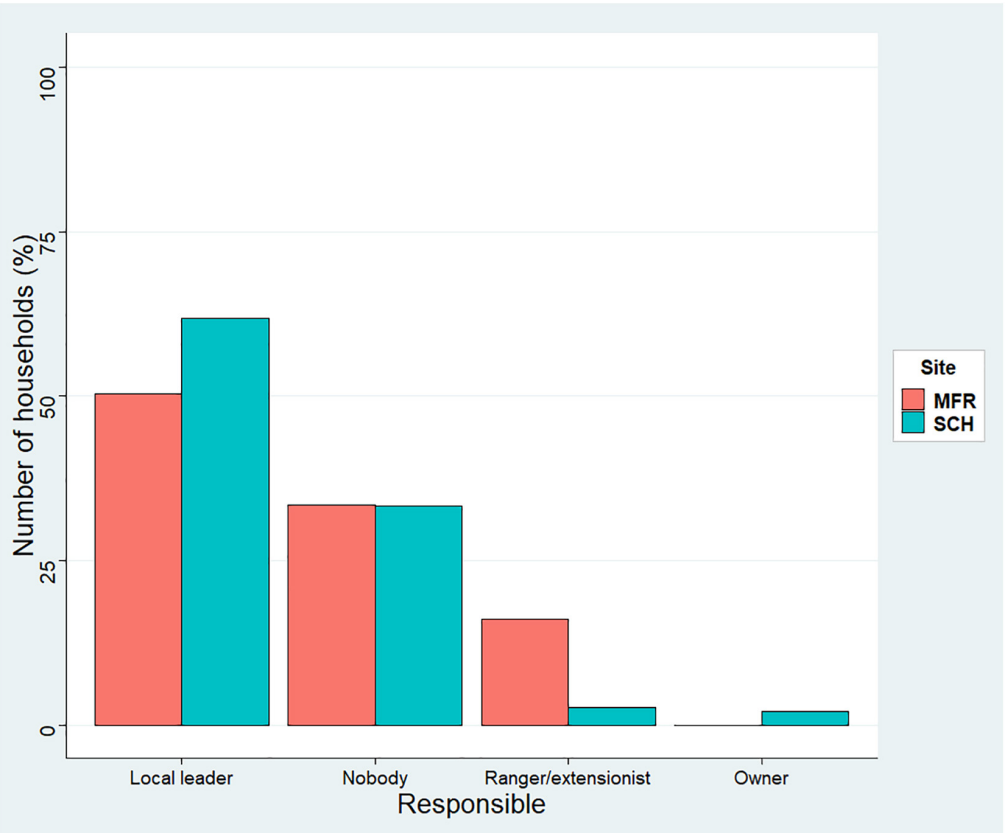

FIGURE 3 | Households' perception about the institution responsible for control of forest use in MFR and SCH.

use land and consider themselves as rightful owners despite the basic premise that land and natural resources belong to the state (Bruna, 2019). Another difference is the human/elephant conflict in MFR. The area is inhabited by a small number of elephants that sometimes invade agricultural fields (Virtanen et al., 2020).

Fallow is a common agricultural practice for 90.6% of households in MFR and is a valuable source of poles, firewood, medicinal plants, honey, and grazing. Shifting cultivation is practiced by 13.9% of households in SCH, and the remaining respondents found fallowing unsuitable because of space shortage (44.4%) or good soil fertility (34.7%). The households in SCH tend to gather non-timber forest products from the forest instead of fallow (**Table 4**).

Livelihood Strategies

Crop cultivation and livestock are the dominant economic activity in both study areas (**Table 5**). The agricultural and livestock products are intended for their own consumption and trade in both areas, although road access is a limiting factor in SCH. Nonetheless, in SCH, 10% more households are engaged in commercializing agricultural products than in Moribane. The difference is even greater with regard to commercialization of livestock/poultry. In SCH, 83.3% of households commercialize animal products against 47.9% in Moribane. A considerable difference is also observed in trading honey, with 41.0% of households selling this product in MFR, but only 12.5% in SCH (**Table 6**).

More diversification of income sources is observed in SCH. There are several opportunities to generate income outside agriculture based on forest exploitation and employment in agricultural companies producing macadamia and potatoes. In SCH, four families are engaged exclusively in the exploitation of forest resources, such as charcoal production, hunting, and timber. Poles, firewood, and honey are the most traded products (**Table 7**). In MFR, only honey is sold as an additional source of

TABLE 4 | Main source of different non-timber forest products in MFR and SCH (percentage of households).

Forest product	MFR			SCH		
	Field	Fallow	Forest	Field	Fallow	Forest
Hunting	4.0	6.0	0.7	0.7	0.0	22.9
Poles	6.7	70.5	63.8	11.1	17.4	9.7
Fruit	10.7	48.3	34.9	27.8	3.5	30.6
Firewood	31.5	89.3	32.2	0.7	6.3	86.8
Wood	0.7	19.5	26.8	0.0	0.0	2.1
Honey	3.4	49.7	32.2	0.7	2.8	14.6
Medicinal plants	45.0	49.0	26.8	2.1	0.0	4.2

TABLE 5 | Engagement in different livelihood strategies in MFR and SCH (number and percentage of households).

Strategy		MFR		SCH	
		Frequency	Percentage	Frequency	Percentage
On-farm strategies	Staple food	148	99.3	138	95.8
	Vegetables	105	70.5	106	73.6
	Fruit	25	16.8	91	63.2
	Poultry	140	94	120	83.3
	Livestock	82	55	107	74.3
	Cash crop	142	95.3	68	47.2
Off-farm strategies	Odd jobs	17	11.4	11	7.6
	Wage	3	2	19	13.2
	Small business	27	18.1	12	8.3
	Fishing	0	0	5	3.5
Forest-based strategies	Medicinal plants	83	55.7	9	6.3
	Hunting	10	6.7	33	22.9
	Honey	59	39.6	26	18.1
	Charcoal	0	0	5	3.5
	Firewood	149	100	135	93.8
	Poles	148	99.3	55	38.2
	Timber	65	43.6	3	2.1

TABLE 6 | Commercialization of different products in MFR and SCH (number and percentage of households).

Products	MFR		SCH	
	Frequency	%	Frequency	%
Livestock/poultry	69	47.9	120	83.3
Agriculture	106	73.6	121	84.0
Honey	59	39.6	18	12.5

TABLE 7 | Gathering forest products for subsistence and/or for trade in MFR and SCH (percentage of households).

Forest product	MFR			SCH		
	Subsistence	Trade	Both	Subsistence	Trade	Both
Poles	99.3	0.0	0.0	27.1	2.8	8.3
Firewood	100.0	0.0	0.0	81.3	1.4	11.1
Wood	43.6	0.0	0.0	0.7	1.4	0.0
Honey	1.3	22.1	16.2	6.9	2.1	9.0
Medicinal plants	55.7	0.0	0.0	4.2	0.7	1.4
Hunting	6.7	0.0	0.0	17.4	0.7	4.9
Charcoal	0.0	0.0	0.0	0.7	2.8	0.0

income. In both areas, forest products play an important role in the households' subsistence use.

If we consider the minimum wage for the agricultural sector, which was 61.6 EU/month in 2019 (WageIndicator Foundation, 2019), 91.3% of households in MFR earn less than the minimum wage compared to 85.4% of families in SCH. Whereas households in SCH are quite evenly distributed among income intervals, 50% received 28€ or less, and in Moribane, the average monthly income of 67.8% of the households ranged from 28.1€ to 70.0€ (**Figure 4**).

Factors Affecting Households' Decisions to Clear Forests

The analysis of the variables indicates that conservation measures do not influence the households' decision to clear forest in the conservation area in MFR and play only a small role in SCH, where the probability for forest clearing is 10% (**Table 8**). The coefficient is positive in the protected area and negative in the open-access area.

Demographic characteristics relative to age, gender, and education level of respondents do not contribute in a significant manner to deforestation, although they behave as was expected. The increase in household members old enough to work does not seem relevant for deforestation in either area, although the direction is negative. The size of the agricultural plot is significant in MFR while in SCH it plays a minor role—although it correlates with forest cover changes in both areas. This is especially salient in MFR, where households cultivate larger areas than in SCH. Distance to roads is equally significant in both areas. In both places, the households who live distant from roads have a higher probability to deforest than those who live near roads, contradicting the expectations.

Level of income is related to deforestation in Moribane, with an 8% probability to clear forest when income increases. In SCH, an increase in income decreases the probability to clear forest by 13%. Regarding the livelihood strategies, there is a negative direction for the on-farm strategy in both sites, showing that more diversified agricultural production correlates with reduced deforestation. The effect of an on-farm strategy is significant in SCH, with 26% less probability to deforest by households more engaged in crop and livestock diversification than in households with less variety. The off-farm and forest-based strategies are relevant for MFR, although in opposite directions.

DISCUSSION

Households' Perception on Forest Resource Accessibility

The prevalent perception among MFR households is that the legal conservation status does not limit their activities. In both areas, the traditional rules are important means to control access to forest resources. The traditions, belief, cultural rules, and local habits play an important role in natural resource management at the community level (Araia et al., 2020). According to Alfredo (2009), the land is seen by communities as a sacred and communal property. Hence, traditional authorities are vested with powers to settle norms and rules of its use rights and ownership. The turbulent history of the areas and the delicate political situation have also reduced the population's trust in government initiatives, negatively affecting conservation efforts (Virtanen, 2019). The perception of unrestricted use of forest resources may be a sign of moderate application of protection measures and governmental agencies' consideration of local power structures or weak enforcement of laws. Policy without proper implementation and enforcement of rules will

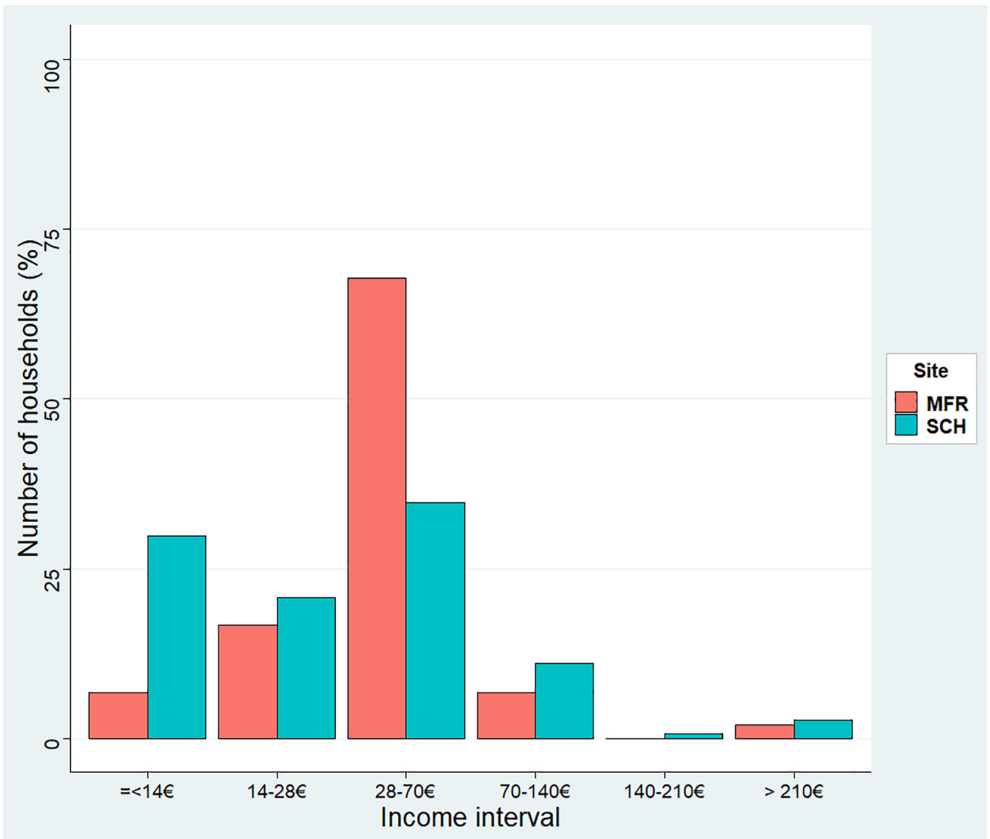

FIGURE 4 | Percentage of households in MFR and SCH per income (in €).

not influence community-based forest resource conservation and management (Yami and Mekuria, 2022). Alternatively, a strict ban on natural resource use appears insufficient as a conservation tool. Studies show that it often creates revolt, increasing unsustainable use (Milgroom, 2012; Givá and Raitio, 2017; Wamir et al., 2017). It also negatively impacts livelihood choices, especially within communities in remote and poor areas with limited options for employment and income generation, while it has marginal impact on reducing deforestation (Angelsen et al., 2014). The relative proximity of forested areas also contributes to the households' perception about easy access to forest resources. In MFR, more than 40% of households collect forest products from fallows and, to a lesser extent, from the forest, whereas in SCH, people tend to use the forest as the main source. Studies show that fallowing can play a relevant role as a source of forest products and thus reduce deforestation (Dewi et al., 2017; Heinimann et al., 2017).

Conservation Impact on Local Household Strategies

Our study identified a set of livelihood strategies developed by households. They seem diverse but still heavily reliant on natural resources. The households combine on-farm, off-farm, and forest-based activities to fulfill their daily needs. Crop growing and livestock are predominant activities in both areas and typical for Mozambican rural areas (Kidane et al., 2019). The advantage of livelihood strategies based on agriculture and livestock is their short-term compensation. The results are immediate, unlike forest usage. The rapid reward for effort implemented is a strong motivation (Miller et al., 2021). Restrictions in access to forest resources can lead to increased dependency on agriculture, observed in the MFR, so the environmental agencies aid households to diversify livelihoods and ameliorate agricultural practices (Virtanen et al., 2020). Regarding the agricultural practice in open-access areas, there is a focus on improving productivity and intensification to reduce shifting agriculture and ensure food security (Cammaer, 2016). Government policies that tend to intensify agricultural productivity and increased market opportunities can induce farmers to move from shifting agriculture to more intensive agricultural practices (Dobler-Morales et al., 2020). Although the differences in the selection of livelihood strategies are not considerable, we can see that off-farm activity, livestock, and fruit gathering play a more important role in SCH than in MFR. However, it is worth mentioning that diversification has little impact on income generation, with majority of families earning less than minimum wage. Cash crop cultivation is more notable in MFR than in SCH. Livelihood diversification and land use intensification at

TABLE 8 | Estimation results of logit regression for deforestation at households' level by study areas, MFR and SCH.

Variable	MFR			SCH		
	Coeff.	*p*	Odds ratio	Coeff.	*p*	Odds ratio
Human capital						
Respondent age	−0.025		0.975	−0.050		0.951
Education level of respondent	−0.017		0.983	−0.147		0.864
Gender	0.032		1.032	0.031		1.032
Number of household members aged 15+	−0.003		0.997	−0.053		0.948
Physical capital						
Size of agriculture plot	0.168	***	1.183	0.156	.	1.169
Distance to the nearest road	0.082	**	1.085	0.273	**	1.314
Trading place	0.063		1.065	−0.093		0.911
Social capital						
Conservation limitations in access to forest	0.005		1.005	−0.105	*	0.901
Natural capital						
Distance to forest edge	−0.001		0.999	0.040		1.041
Financial capital						
Income	0.083		1.087	−0.144		0.866
On-farm strategies	−0.029		0.971	−0.297	*	0.743
Off-farm strategies	−0.050	*	0.951	0.036		1.037
Timber based	0.216	**	1.241	0.024		1.024
Intercept	0.433	**		0.880	**	
Number of observations	149			144		

*Significance codes: 0 "***" 0.001 "**" 0.01 "*" 0.05 "." 0.1 " " 1.*

the smallholder level are seen as viable paths to accomplish forest transition (Rudel et al., 2020). The conservation agenda should consider agriculture-based livelihood strategies (Zafra-Calvo and Moreno-Peñaranda, 2018).

Forests in the study areas are used to provide plenty of products constituting an important component of households' subsistence strategy and income generation (Guedes, 2008). Due to conservation status, trade of tree-derived products is reduced in MFR, so households earn money mainly from the sale of honey, cash crops, and off-farm activities. Our study shows that honey production is an important livelihood strategy for households in MFR, with 40% of families engaged in it. Beekeeping is also used as a protection against elephants (Virtanen et al., 2020). In the open-access area, forest product trade is more diversified, and 3% of households rely exclusively on forest exploitation for income. There is a moderate positive correlation between the perceptions about limitations in accessing the forest and the off-farm and on-farm strategies in MFR, indicating that households tend to adjust strategies to existing conditions. The analysis revealed only a weak effect of conservation on the households' decisions in the open-access area and none in the protected area.

Impact of Livelihood Strategy Diversification on Deforestation

In MFR, off-farm activities, although developed by a smaller number of households than that in SCH, play an important role in reducing deforestation. The time spent outside indicates less time for agricultural activity within the household, and the earnings help with expenses. We could not see this correlation in the open-access area, where increased job opportunities do not reduce deforestation, as seen by Angelsen (2010). African rural households tend to diversify, rather than specialize their livelihoods, and wages are seen as an additional activity to buy goods that the household cannot produce (Alobo Loison, 2015). Off-farm activities decrease the probability for deforestation, whereas forest-based livelihoods correlate with increase in deforestation due to the extraction of forest resources for daily use. In our study, probit results showed that engagement in forest-based strategies could increase deforestation instead of reducing it, which is in line with previous findings (MacKenzie et al., 2017).

In attempting to reduce human/elephant conflict, decrease deforestation, and increase households' income, the CNP authorities introduced beekeeping in the conservation area (Virtanen et al., 2020). Honey is currently the only NTFP commercialized in MFR. The lower income levels in MFR, compared with SCH, indicate little impact by the honey trade on household income, which is in line with other studies (Kimengsi et al., 2019). Although beekeeping is considered a viable activity that should decrease deforestation (Chanthayod et al., 2017; Mudzengi et al., 2020), our results show that, in MFR, this is not yet observed. Attempts to use apiculture in MFR as an alternative income source and approach to reduce the forest clearing date to 1998, with the implementation of the conservation project on the Chimanimani area (De Matos, 2011). Although the honey production experienced commercialization problems, the beekeeping promotion was not abandoned by authorities and new attempts were made (De Matos, 2011; Virtanen, 2019). In 2018, the Sustainable Development National Fund again distributed hives to communities living in CNP, including MFR (FNDS, 2018). The positive impact of the apiculture on forest conservation will probably be observed in the future, but this aspect requires more and better studies. Lowore et al. (2018) found contradicting evidences about the role of beekeeping in forest conservation among different African countries and associated it to economic and social factors, mainly land use related. Evidence from a Tanzanian study on traditional beekeeping in a forest reserve shows no considerable difference on forest conservation among areas with and without beekeeping practice (Augustino et al., 2016). The difference in income distribution shows that efforts to add honey production as an income source in the conservation area do not translate into better income for households and their willingness to protect forests. The financial motivation is pointed out as an important factor influencing the willingness to conserve forest (Sutcliffe et al., 2012; Musinguzi et al., 2018). This shows that the implementation of conservation policies should better address the socioeconomic aspects and, principally, poverty reduction (Miller et al., 2021). Connecting the preservation of natural resources with the economic utility of resources as attractive assets is—in theory—a good strategy. It produces incentives for local communities and allows them to be a part

of an economic network (Dondeyne et al., 2012). However, despite the importance of forest products for livelihoods, agricultural production has more economic value for households in the study areas.

Our study observed increasing deforestation in both areas, especially in the protected area, despite conservation efforts from government and civil society agencies. This corroborates other studies, which show limited effectiveness of conservation areas to halt deforestation (Shah and Baylis, 2015; Spracklen et al., 2015; Wade et al., 2020). Reduction of the forest area in both study areas can be attributed, among other reasons, to the underlying driver of population growth, with agriculture as the main direct driver, which is in line with previous studies on the drivers of deforestation (Ryan et al., 2014; Sitoe et al., 2016; MITADER, 2018a). Babigumira et al. (2014) found that an increase in agricultural area augments the probability for forest clearing if the farm size is 3 ha or less and that increases in the size of the plot heighten the probability of deforestation. Households intensify their exploration of forest resources, including conversion to agriculture, when there are limited opportunities to generate income (Angelsen et al., 2014; Belcher et al., 2015). The results are also in line with the findings of Babigumira et al. (2014), which indicate that access to markets and the existence of good road connections are important factors in forest cover change in the initial phases of forest transition, because agriculture is more rewarding than low-disturbance forest exploration. Difficulty in reaching a market for agricultural products discourages production, thus reducing the need to increase the cultivated area (Schmook and Vance, 2009). In the study areas, access to roads and markets determines the feasibility of selling products. This is notable, especially in SCH, where the population lives in hard-to-reach areas with no passable roads. The feeder road connecting Chôa-Sede and Catandica, the district headquarters, does not allow safe traffic during the rainy season. The inhabitants from communities must walk long distances to reach Chôa-Sede and use animal traction to transport goods. The lower deforestation rates in SCH point to the lower opportunities for trade due to weak road infrastructure, as well as a preference for economic activities other than agriculture, notably livestock breeding, which does not require the clearing of forest since open grasslands are available. In particular, we see the influence of road improvement in MFR and better trade opportunities as a trigger to increase agricultural areas. Our model showed that access to roads leading to better trade is a more relevant aspect for households than conservation policies. The forest cover reduction is most notable for MFR after 2010, which is especially interesting. In 2010, the CNP management plan was drawn up, preceded by community consultations and awareness campaigns (Ghiurghi et al., 2010). It could be expected that extensive awareness campaigns and revitalization of conservation area would have a positive impact and reduce deforestation after 2010. The increased deforestation between 2014 and 2017 in MFR probably occurred due to improvement in the main road, which triggered the commerce of agricultural products, especially bananas (Eriksson, 2020). Good road connection and proximity with large banana production areas influence the choice of households in MFR to engage in agricultural activities (Guedes, 2008).

The existing conservation policies only reduce the economic opportunities but do not decrease the attractiveness of conservation areas for a new settlement. Once someone is assigned a piece of land by traditional authorities or receives land from a family member, that person finds himself/herself entitled to change land use/cover according to necessities. Considering the existence of large areas covered by forests and the tendency for population to increase, there is a great probability that deforestation will continue as the need for new agricultural plots will increase.

CONCLUSION

The proper design of conservation policies needs to understand aspects relevant to households' selection of specific livelihood strategies. Those choices have a direct impact on the conversion of forests to other land uses. Independent of protection status, households develop their activities relying on natural resources. Based on survey results, we identify three main groups of livelihood strategies in the study areas. The preference goes to agriculture-related activities because they are more attractive for farmers than the conservation of forest resources. There is more probability of commercializing crops than forest products, and the short-term reward and immediate satisfaction of households' fundamental needs will always prevail over long-term conservation goals. The main difference in livelihood strategies between the protected and open-access areas is the possibility to trade the forest products. While households in the protected area only commercialize honey, in the open-access area, they commercialize poles, bush meat, timber, and firewood. They also commercialize honey, but to a lower extent than that in the conservation area.

Deforestation in the study areas is increasing, and there are few chances that conservation restrictions will reduce deforestation on their own. Access to roads is a common and important element for both areas, significantly influencing households' decisions. In addition, engagement in off-farm and forest-based activities in the conservation area and on-farm strategies and limitations imposed by traditional conservation practices in the open-access areas both have an impact. One of the options could be creating more opportunities for off-farm employment in small commerce to reduce the direct dependency on natural resources.

Forest resources are an important part of the households' livelihood strategies, but forest conversion to other uses—notably agriculture—is more important to get income and subsistence goods. Forest products only complement goods obtained from agriculture as a source of energy, food, and additional income. Relatively low population density and proximity to forested areas quite easily providing various goods maintain the households' perception of very little or no restrictions in forest access and use. This perception may lead to reduced concern about forest management and protection.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

JM and AS conceptualized the research idea. JM carried out the fieldwork and secondary data collection, performed the analysis, interpreted the results, and wrote the manuscript. AS, SL, and PV provided the methodology, contribution to the interpretation of results, critical feedback, and helped in the final version of the manuscript. AS and PV supervised the research. All authors contributed to the article and approved the submitted version.

FUNDING

This research received funds from the Higher Education Institutions Institutional Cooperation Instrument (HEI ICI) through the Sustainable Management of Natural Resources in Mozambique (SuMNatuRe) project coordinated by the University of Jyväskylä, Eduardo Mondlane University (Mozambique), Zambeze University (Mozambique), and the University of Eastern Finland. The scholarship of the JM was funded by the Instituto de Bolsas de Estudo of Mozambique (grant 125/2019/024.IBE).

ACKNOWLEDGMENTS

We would like to express our appreciation to Francisco Domingos Francisco, a Ph.D. student at Eduardo Mondlane University, for his very valuable participation in the field survey in MFR. We would like to thank the District Governments of Barue and Sussundenga for the assistance provided during the data collection and express our gratitude to the HEI ICI and SuMNatuRe project and the Instituto de Bolsas de Estudo de Moçambique for financial support. Furthermore, we would like to thank Pedro Cossa, Gerald Lubega, and University of Jyväskylä for the language editing.

REFERENCES

Alfredo, B. (2009). *Alguns Aspectos Do Regime Jurídico Da Posse E Do Direito De Uso E Aproveitamento Da Terra E Os Conflitos Emergentes Em Moçambique*. Pretoria: University of South Africa, 354.

Alobo Loison, S. (2015). Rural livelihood diversification in sub-saharan africa: a literature review. *J. Dev. Stud.* 51, 1125–1138. doi: 10.1080/00220388.2015.1046445

ANAC (2021). *Plano De Maneio Do Parque Nacional De Chimanimani 2021 – 2030*. Maputo: ANAC.

Angelsen, A. (2010). Policies for reduced deforestation and their impact on agricultural production. *Proc. Natl. Acad. Sci. U.S.A.* 107, 19639–19644. doi: 10.1073/pnas.0912014107

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N. J., Bauch, S., et al. (2014). Environmental income and rural livelihoods: a global-comparative analysis. *World Dev.* 64, S12–S28. doi: 10.1016/j.worlddev.2014.03.006

Araia, M. G., Chirwa, P. W., and Syampungani, S. (2020). Do strictly protected areas protect vulnerable local tree species better than human land use? Disentangling conservation value from biodiversity value. *J. Nat. Conserv.* 58:125919. doi: 10.1016/j.jnc.2020.125919

Ashraf, J., Pandey, R., and de Jong, W. (2016). Assessment of bio-physical, social and economic drivers for forest transition in Asia-Pacific region. *For. Policy Econ.* 76, 35–44. doi: 10.1016/j.forpol.2016.07.008

Augustino, S., Kashaigili, J. J., and Nzunda, E. F. (2016). Impact of traditional beekeeping on *Mgori village* land forest reserve in Singida District, Tanzania. *Tanzania J. For. Nat. Conserv.* 86, 1–11.

Babigumira, R., Angelsen, A., Buis, M., Bauch, S., Sunderland, T., and Wunder, S. (2014). Forest clearing in rural livelihoods: household-level global-comparative evidence. *World Dev.* 64, S67–S79. doi: 10.1016/j.worlddev.2014.03.002

Balas, M., Carrilho, J., and Lemmen, C. (2021). The fit for purpose land administration approach - connectiong people, processes and technology in mozambique. *Land* 10:818. doi: 10.3390/land10080818

Basnyat, B. (2009). *Impacts of Demographic Changes on Forests and Forestry in Asia and the Pacific. Agriculture, 1–82*. Available online at: http://www.fao.org/3/am253e/am253e.pdf (accessed June 2, 2021).

Belcher, B., Achdiawan, R., and Dewi, S. (2015). Forest-based livelihoods strategies conditioned by market remoteness and forest proximity in Jharkhand, India. *World Dev.* 66, 269–279. doi: 10.1016/j.worlddev.2014.08.023

Bleyer, M., Kniivilä, M., Horne, P., Sitoe, A., and Falcão, M. P. (2016). Socio-economic impacts of private land use investment on rural communities: industrial forest plantations in Niassa, Mozambique. *Land Use Policy* 51, 281–289. doi: 10.1016/j.landusepol.2015.11.011

Bruna, N. (2019). Land of plenty, land of misery: synergetic resource grabbing in Mozambique. *Land* 8:113. doi: 10.3390/land8080113

Cammaer, R. (2016). *Tracing Sustainable Agriculture In Mozambique: From Policy To Practice*. London: IIED.

Chanthayod, S., Zhang, W., and Chen, J. (2017). People's perceptions of the benefits of natural beekeeping and its positive outcomes for forest conservation: a case study in Northern Lao PDR. *Trop. Conserv. Sci.* 10:1940082917697260. doi: 10.1177/1940082917697260

Charlery, L., Nielsen, M. R., Meilby, H., and Smith-Hall, C. (2016). Effects of new roads on environmental resource use in the Central Himalaya. *Sustainability* 8, 1–20. doi: 10.3390/su8040363

Chiziane, E., Gift, R., Kibugi, R., Wardell, D. A., Cordonier Segger, M.-C., and Haywood, C. (2015). *Legal Frameworks Enabling Sustainable Land-Use Investment In Mozambique: Current Strengths And Opportunities For Improvement*. Bogor Regency: CIFOR, 73. doi: 10.17528/cifor/005759

Cizek, A. (2009). Birds of the serra choa, mozambique, with first records for mozambique and new localities for eastern highlands endemics. *Honeyguide* 55, 11–21.

De Matos, E. A. (2011). *A Nova Abordagem De Gestão De Áreas De Conservação E Suas Implicações Socioespaciais: O Caso De Chimanimani No Centro De Moçambique. Univ. Fed. Do Rio Gd. Do Sul, 203*. Available online at: https://www.lume.ufrgs.br/bitstream/handle/10183/29553/000777536.pdf (accessed August 16, 2021).

Dewi, S., Van Noordwijk, M., Zulkarnain, M. T., Dwiputra, A., Hyman, G., Prabhu, R., et al. (2017). Tropical forest-transition landscapes: a portfolio for studying people, tree crops and agro-ecological change in context. *Int. J. Biodivers. Sci. Ecosyst. Serv. Manag.* 13, 312–329. doi: 10.1080/21513732.2017.1360394

DFID (1999). *Sustainable Livelihoods Guidance Sheets 1-2*. London: DFID.

Dobler-Morales, C., Roy Chowdhury, R., and Schmook, B. (2020). Governing intensification: the influence of state institutions on smallholder farming strategies in Calakmul, Mexico. *J. Land Use Sci.* 15, 108–126. doi: 10.1080/1747423X.2019.1646334

Dondeyne, S., Kaarhus, R., and Allison, G. (2012). "Nature conservation, rural development and ecotourism in central mozambique: which space do local communities get?," in *Making Sense of Place: Mutidisciplinary Perspectives*, eds I. Convery, G. Corsane, and P. Davis (Woodbridge: The Boydell Press), 291–301.

Eriksson, L. (2020). *Assessment of Land Use Change in Moribane Forest Reserve, Mozambique by Satellite Image Classification*. Jyväskylä: University of Jyväskylä.

FAO and UNEP (2020). *The State of the World's Forests 2020. Forests, Biodiversity And People*. Rome: FAO.

FNDS (2018). *Projectos Comunitários Mudam A Vida Das Comunidades Na Reserva Nacional De Chimanimani*. https://www.fnds.gov.mz/index.php/en/resources/highlights/74-projectos-comunitarios-mudam-a-vida-das-comunidades-na-reserva-nacional-de-chimanimani (accessed November, 20, 2021).

FNDS (2019). *Relatório do Mapa de Cobertura Florestal de Moçambique 2016. Maputo. 105*. Available online at: https://www.fnds.gov.mz/mrv/index.php/documentos/relatorios/39-relatorio-de-mapa-de-cobertura-florestal-2016-versao-2/file (accessed June 15, 2020).

Galiatsatos, N., Donoghue, D. N. M., Watt, P., Bholanath, P., Pickering, J., Hansen, M. C., et al. (2020). An assessment of global forest change datasets for national forest monitoring and reporting. *Remote Sens.* 12:1790. doi: 10.3390/rs12111790

Garekae, H., Thakadu, O. T., and Lepetu, J. (2017). Socio-economic factors influencing household forest dependency in Chobe enclave, Botswana. *Ecol. Process.* 6:40. doi: 10.1186/s13717-017-0107-3

Ghiurghi, A., Dondeyne, S., and Bannerman, J. H. (2010). *Chimanimani National Reserve Management Plan*. Maputo: MITUR.

Givá, N., and Raitio, K. (2017). 'Parks with people' in mozambique: community dynamic responses to human-elephant conflict at limpopo national park. *J. South. Afr. Stud.* 43, 1199–1214. doi: 10.1080/03057070.2017.1374810

Governo de Moçambique (2014). *Lei de Conservação, 20 de Junho de 2014, Lei n. o 16/2014. 12*. Available online at: https://www.biofund.org.mz/biblioteca_virtual/lei-n-o-162014-de-20-de-junho-lei-da-conservacao-da-biodiversidade/html (accessed March 12, 2018).

Greene, H. W. (2002). *Econometric Analysis*, 5th Edn. Engelwood Cliffs, NJ: Prentice-Hall.

Guedes, B. S. (2008). *Custo de Oportunidade de Conservação e Valor de Existência da Reserva Florestal de Moribane*. Maputo: UEM, 117.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., et al. (2013). High-resolution global maps of 21st-century forest cover change. *Science* 342, 850–853. doi: 10.1126/science.1244693

Heinimann, A., Mertz, O., Frolking, S., Christensen, A. E., Hurni, K., Sedano, F., et al. (2017). A global view of shifting cultivation: recent, current, and future extent. *PLoS One* 12: e0184479. doi: 10.1371/journal.pone.0184479

INE (2018). *Anuário Estatístico da Província de Manica - 2017*. Lisbon: Instituto Nacional de Estatística Manica.

Jansen, L. J. M., Bagnoli, M., and Focacci, M. (2008). Analysis of land-cover/use change dynamics in manica province in mozambique in a period of transition (1990-2004). *For. Ecol. Manage.* 254, 308–326. doi: 10.1016/j.foreco.2007.08.017

Kidane, S. M., Lambert, D. M., Eash, N. S., Roberts, R. K., and Thierfelder, C. (2019). Conservation agriculture and maize production risk: the case of Mozambique smallholders. *Agron. J.* 111, 2636–2646. doi: 10.2134/agronj2018.05.0331

Kimengsi, J. N., Pretzsch, J., Kechia, M. A., and Ongolo, S. (2019). Measuring livelihood diversification and forest conservation choices: insights from rural cameroon. *Forests* 10, 1–16. doi: 10.3390/f10020081

Lowore, J., Meaton, J., and Wood, A. (2018). African forest honey: an overlooked NTFP with potential to support livelihoods and forests. *Environ. Manage.* 62, 15–28. doi: 10.1007/s00267-018-1015-8

MacKenzie, C. A., Salerno, J., Hartter, J., Chapman, C. A., Reyna, R., Tumusiime, D. M., et al. (2017). Changing perceptions of protected area benefits and problems around Kibale National Park Uganda. *J. Environ. Manage.* 200, 217–228. doi: 10.1016/j.jenvman.2017.05.078

Malleux, J. (1980). *Avaliação dos Recursos Florestais da República Popular de Moçambique*. Maputo: MInistério de Agricultura.

Marzoli, A. (2007). *Relatório do Inventário Florestal Nacional. Direcção Nacional de Terras e Florestas*. Maputo: Ministério de Agricultura.

Matos, A., Barraza, L., and Ruiz-Mallén, I. (2021). Linking conservation, community knowledge, and adaptation to extreme climatic events: a case study in Gorongosa National Park, Mozambique. *Sustainability* 13:6478. doi: 10.3390/su13116478

Milgroom, J. (2012). *Elephants of Democracy: An Unfolding Process of Resettlement in the Limpopo National Park*. Wageningen: Wageningen University, 322.

Miller, D. C., Mansourian, S., Gabay, M., Hajjar, R., Jagger, P., Kamoto, J. F. M., et al. (2021). Forests, trees and poverty alleviation: Policy implications of current knowledge. *For. Policy Econ.* 131:102566. doi: 10.1016/j.forpol.2021.102566

MITADER (2018b). *Inventário Florestal Nacional. Report, 180*. Available online at: https://www.fnds.gov.mz/mrv/index.php/documentos/relatorios/26-inventario-florestal-nacional/file (accessed September 11, 2019).

MITADER (2018a). *Desflorestamento em Moçambique 2003-2016. 42*. Available online at: http://www.biofund.org.mz/wp-conent/uploads/2019/01/1548412539-Estimativas do Desmatamento Florestal em Moçambique.pdf (accessed September 6, 2021).

Mitader (2019). *Agenda Estrategica 2019 -2035 e Programa Nacional de Florestas*. Maputo: MITADER.

Mudzengi, C., Kapembeza, C. S., Dahwa, E., Taderera, L., Moyana, S., and Zimondi, M. (2020). Ecological benefits of apiculture on savanna rangelands. *Bee World* 97, 17–20. doi: 10.1080/0005772x.2019.1701797

Müller, T., Sitoe, A., and Mabunda, R. (2005). *Assessment of the Forest Reserve Network in Mozambique Table of Contents*. Available online at: http://cgcmc.gov.mz/attachments/article/100/548946e10cf2ef344790ae27.pdf (accessed November 7, 2018).

Musinguzi, P., Bosselmann, A. S., and Pouliot, M. (2018). Livelihoods-conservation initiatives: Evidence of socio-economic impacts from organic honey production in Mwingi, Eastern Kenya. *For. Policy Econ.* 97, 132–145. doi: 10.1016/j.forpol.2018.09.010

Mussanhane, J., Nhamuco, L., and Virtanen, P. (2000). "A traditionally protected forest as a conservation area: a case study from Mozambique," in *Forests, Chiefs and Peasants in Africa: Local management Of Natural Resources In Tanzania, Zimbabwe and Mozambique*, eds P. Virtanen and M. Nummelin (Joensuu: University of Joensuu), 89–115.

Nube, T. G., dos Santos, A. S. J., Timofeiczyk, R., and Silva, I. C. (2016). Impactos socioeconómicos das plantações florestais no niassa, moçambique. *Flor. Ambient* 23, 52–60. doi: 10.1590/2179-8087.038813

Ojeda Luna, T., Eguiguren, P., Günter, S., Torres, B., and Dieter, M. (2020). What drives household deforestation decisions? Insights from the ecuadorian lowland rainforests. *Forests* 11, 1–20. doi: 10.3390/f11111131

Park, M. S., and Youn, Y. C. (2016). Reforestation policy integration by the multiple sectors toward forest transition in the Republic of Korea. *For. Policy Econ.* 76, 45–55. doi: 10.1016/j.forpol.2016.05.019

Pir Bavaghar, M. (2015). Deforestation modelling using logistic regression and GIS. *J. For. Sci.* 61, 193–199. doi: 10.17221/78/2014-JFS

RStudio Team (2020). *RStudio: Integrated Developement for R*. Boston, MA: RStudio, PBC.

Rudel, T. K., Meyfroidt, P., Chazdon, R., Bongers, F., Sloan, S., Grau, H. R., et al. (2020). Whither the forest transition? Climate change, policy responses, and redistributed forests in the twenty-first century. *Ambio* 49, 74–84. doi: 10.1007/s13280-018-01143-0

Ryan, C. M., Berry, N. J., and Joshi, N. (2014). Quantifying the causes of deforestation and degradation and creating transparent REDD+ baselines: a method and case study from central Mozambique. *Appl. Geogr.* 53, 45–54. doi: 10.1016/j.apgeog.2014.05.014

Rylance, A. (2016). Estimating tourism's contribution to conservation area financing in mozambique. *Tour. Hosp. Res.* 17, 24–33. doi: 10.1177/1467358415613119

Saket, M. (1994). *Report on the Updating of the Exploratory National Forest Inventory*. Maputo: DNFFB.

Schmook, B., and Vance, C. (2009). Agricultural policy, market barriers, and deforestation: the case of mexico's southern yucatán. *World Dev.* 37, 1015–1025. doi: 10.1016/j.worlddev.2008.09.006

Shah, P., and Baylis, K. (2015). Evaluating heterogeneous conservation effects of forest protection in Indonesia. *PLoS One* 10:e0124872. doi: 10.1371/journal.pone.0124872

Sheila de Menezes Advogados (2017). *Análise Do Impacto Da Reforma Legal No Sector Florestal. Iied Relatório Do País*. Available online at: http://pubs.iied.org/13590PIIED ISBN 978-1-78431-532-0 (accessed March 22, 2021).

Sitoe, A., and Guedes, B. S. (2015). Community forestry incentives and challenges in Mozambique. *Forests* 6, 4558–4572. doi: 10.3390/f6124388

Sitoe, A., Macandza, V., Remane, I., and Mamugy, F. (2015). *Mapeamento De Habitats De Moçambique: Criando as Bases para Contrabalanços De Biodiversidade em Moçambique*. Maputo: CEAGRE, 60. doi: 10.13140/RG.2.1.1769.1607

Sitoe, A., Remane, I., Ribeiro, N., Falcão, M. P., Mate, R., Nhamirre, J., et al. (2016). *Identificação E Análise Dos Agentes E Causas Directas E Indirectas De Desmatamento E Degradação Florestal Em Moçambique Relatório Final. 1–36*. Available online at: http://www.dinaf.gov.mz/pirf_mreddplus/attachments/article/121/Pt_Report on deforestation causes.pdf (accessed November 27, 2017).

Spracklen, B. D., Kalamandeen, M., Galbraith, D., Gloor, E., and Spracklen, D. V. (2015). A global analysis of deforestation in moist tropical forest protected areas. *PLoS One* 10:e0143886. doi: 10.1371/journal.pone.0143886

Sunderland, T., Achdiawan, R., Angelsen, A., Babigumira, R., Ickowitz, A., Paumgarten, F., et al. (2014). Challenging perceptions about men, women, and forest product use: a global comparative study. *World Dev.* 64, S56–S66. doi: 10.1016/j.worlddev.2014.03.003

Sutcliffe, J. P., Wood, A., and Meaton, J. (2012). Competitive forests - making forests sustainable in south-werst Ethiopia. *Int. J. Sustain. Dev. World Ecol.* 19, 471–481. doi: 10.1080/13504509.2012.740510

Timberlake, J., Darbyshire, I., Cheek, M., Banze, A., Fijamo, V., Massunde, J., et al. (2016). *Plant Conservation In Communities On The Chimanimani. 69*. Available online at: https://www.kew.org/sites/default/files/Chimanimani Darwin report%2C FINAL.pdf (accessed November 10, 2021).

Ullah, S., Gang, T., Rauf, T., Sikandar, F., Liu, J. Q., and Noor, R. S. (2020). Identifying the socio-economic factors of deforestation and degradation: a case study in Gilgit Baltistan, Pakistan. *GeoJournal*

Virtanen, P. (2002). The role of customary institutions in the conservation of biodiversity: sacred forests in mozambique. *Environ. Values* 11, 227–241. doi: 10.3197/096327102129341073

Virtanen, P. (2019). Making conservation sustainable under unfavourable conditions: the case of Chimanimani National Reserve, Mozambique. *Dev. Pract.* 30, 320–331. doi: 10.1080/09614524.2019.1682521

Virtanen, P., Macandza, V., Goba, P., Mourinho, J., Roque, D., Mamugy, F., et al. (2020). Assessing tolerance for wildlife: human-elephant conflict in Chimanimani, Mozambique. *Hum. Dimens. Wildl.* 26, 411–428. doi: 10.1080/10871209.2020.1834648

Wade, C. M., Austin, K. G., Cajka, J., Lapidus, D., Everett, K. H., Galperin, D., et al. (2020). What is threatening forests in protected areas? A global assessment of deforestation in protected areas, 2001-2018. *Forests* 11:539. doi: 10.3390/F11050539

WageIndicator Foundation (2019). *Salário Mínimo em Moçambique, a partir de 01-04-2018 a 31-03-2019*. Available online at: https://meusalario.org/mocambique/salario/salario-minimo/archive-before-2019/salario-minimo-em-mocambique-a-partir-de-01-04-2018-a-31-03-2019 (accessed 20 August, 2021).

Wamir, A., Tedim, F., and Ntumi, C. (2017). Impacto das políticas de conservação da natureza na dinâmica das comunidades locais no Parque Nacional do Limpopo (Moçambique). *Rev. Argumentos Montes Claros* 14, 275–295.

World Bank (2018). *Mozambique Country Forestry Note*. Washington, DC: World Bank, 1–33. doi: 10.1596/30935

Wunder, S., Angelsen, A., and Belcher, B. (2014). Forests, livelihoods, and conservation: broadening the empirical base. *World Dev.* 64, S1–S11.

Yami, M., and Mekuria, W. (2022). Challenges in the governance of community-managed forests in ethiopia: review. *Sustainability* 14, 1–22. doi: 10.3390/su14031478

Yang, L., Liu, M., and Min, Q. (2019). Natural disasters, public policies, family characteristics, or livelihood assets? The driving factors of farmers ' livelihood strategy choices in a nature reserve. *Sustainability* 11:5423. doi: 10.3390/su11195423

Youn, Y. C., Choi, J., de Jong, W., Liu, J., Park, M. S., Camacho, L. D., et al. (2017). Conditions of forest transition in Asian countries. *For. Policy Econ.* 76, 14–24. doi: 10.1016/j.forpol.2016.07.005

Zafra-Calvo, N., and Moreno-Peñaranda, R. (2018). Exploring local people's views on the livelihood impacts of privately versus community managed conservation strategies in the Ruvuma landscape of North Mozambique-South Tanzania. *J. Environ. Manage.* 206, 853–862. doi: 10.1016/j.jenvman.2017.11.065

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.