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Research Article

Participatory Forest Management and Rural Livelihoods: Evidence from Sagi-Tagata State Forest, Southwestern Ethiopia

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Abstract

In developing countries, participatory forest management (PFM) has emerged as a promising strategy for enhancing forest conservation and boosting rural livelihoods. This research investigates the impact of PFM on household living standards and changes in forest cover in the Sagi-Tagata State Forest, situated in the Alle District of southwestern Ethiopia. A mixed-methods approach was employed, incorporating household surveys (n = 284), focus group discussions, key informant interviews, and analysis of satellite imagery spanning from 2003 to 2023. Data were analyzed using SPSS Version 24 for descriptive statistics, Wilcoxon signed-rank tests to assess livelihood changes before and after PFM, and one-way ANOVA with LSD post hoc tests for income diversification. Binary logistic regression identified factors influencing PFM participation, including education, gender, age, landholding size, training, credit access, and proximity to forests and markets. Cloud-free Landsat images (2003, 2013, 2023) from USGS were used for land use/land cover analysis. The findings reveal that PFM has led to considerable enhancements in income diversification for households and improved access to forest resources. Despite a reduction in forest cover from 89% in 2003 to 62% in 2023, the pace of forest degradation notably slowed following the implementation of PFM. Logistic regression analysis identified education level, access to credit, landholding size, and proximity to forest resources as key factors influencing participation in PFM. These results emphasize that, when underpinned by suitable institutional and economic frameworks, PFM can effectively facilitate sustainable forest management and rural development.

Keywords

Participatory Forest Management, Forest Cover Change, Livelihood Improvement, Income Diversification, Ethiopia

1. Introduction

Forests are crucial for providing ecological, economic, and social services, significantly contributing to biodiversity conservation, climate regulation, and rural livelihoods. However, deforestation and forest degradation continue to be major global issues, especially in developing countries where reliance on forest resources is significant [10]. In Ethiopia, extensive forest loss has been fueled by agricultural expansion, fuelwood gathering, and insecure land tenure systems [3, 7]. The Ethiopian Environment and Forest Research Institute (EEFRI) reports that the country has experienced a substantial

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loss of its natural forest in recent decades, leading to biodiversity decline and heightened vulnerability to climate change [8]. To tackle these issues, Ethiopia implemented Participatory Forest Management (PFM) as a strategy aimed at fostering sustainable forest use while enhancing the livelihoods of communities reliant on forests. PFM transforms forest governance from a state-centric approach to a community-based model, highlighting shared responsibilities, collaborative decision-making, and equitable benefit-sharing among stakeholders [9, 13]. This strategy seeks to empower local communities to sustainably manage forest resources, improve forest conditions, and alleviate poverty [2, 11].

In Ethiopia, Participatory Forest Management (PFM) was officially launched in the late 1990s through pilot programs in areas like Oromia and the Southern Nations, Nationalities, and Peoples' Region (SNNPR), yielding positive results for forest recovery and socio-economic growth [19, 13]. Nonetheless, PFM outcomes differ significantly among regions, shaped by local governance frameworks, community involvement, and institutional support [2, 12]. While many studies have assessed the ecological or livelihood impacts of PFM independently, there are fewer that take a holistic approach, evaluating both forest health and household well-being concurrently. This study addresses this gap by exploring how PFM contributes to enhancing forest cover and rural livelihoods in the Sagi-Tagata State Forest, found in the Alle District of southwestern Ethiopia. In particular, it examines the socio-economic effects of PFM on household livelihood resources and diversification, measures forest cover changes over two decades, and identifies key factors affecting community participation in PFM initiatives.

2. Research Method

2.1. Study Area Description

This study was conducted in the Alle District, located in the Ilu Aba Bor Zone of southwestern Ethiopia. It lies at a latitude of 8 ̊00'00"N and a longitude of 35 ̊39'59.99" E. The district is strategically situated in an ecological zone rich in natural forest resources, bordered by Bacho District to the east, Didu District to the south, Halu District to the west, Nono Salle District to the southwest, and Mattu District to the north. Covering approximately 62,768 square kilometers, 84% of this area is forest land. Other notable land uses are cropland (16.44%), perennial plantations (9%), settlements (9.75%), grasslands (8.78%), and bare land (25%). Gore, the administrative center established in 1874 E.C., is about 620 km southwest of Addis Ababa and 20 km from the zonal capital, Mattu. According to the 2007 population projection by the CSA, the population of Alle District is estimated at 79,795, consisting of 40,957 males (51%) and 38,838 females (48%). In contrast to other parts of Oromia, over 40% of this district is covered by forests. The local economy is predominantly agricultural [1]. Approximately 34,419.8 hectares of the district are forested, with species including *Croton microstachus* (bekenisa), *Albizia gumifera* (Mukerba), and *Cordia Africana* (Wadesa). The largely natural forest provides various services to the local population and contains 65 hectares of indigenous and exotic plants, such as *Acokanthera schimperi* (keraro) and Bahirzaf (Eucalyptus). Wildlife in this forest includes Kebero, Warabessa (hyena), and monkeys [1].

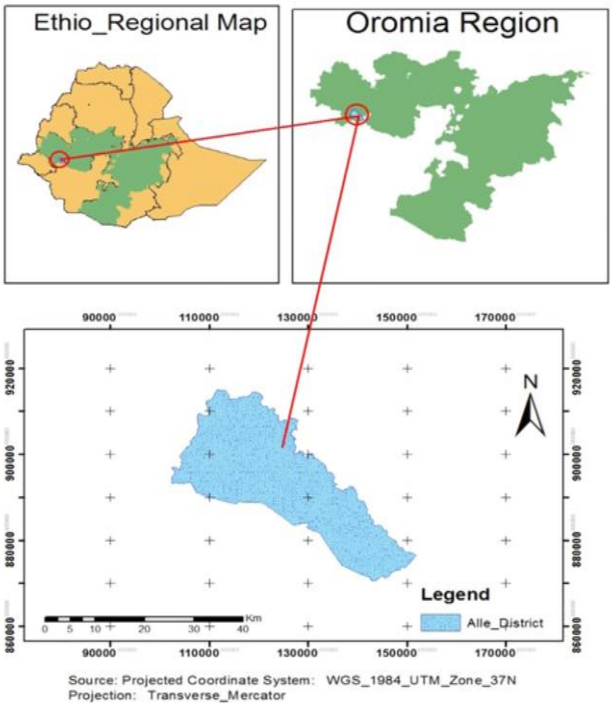


Figure 1. *Map of the study area, Source: Own, Arch-GIS.*

2.2. Research Method

This study employed a mixed-methods approach combining both qualitative and quantitative data collection and analysis to assess the role of Participatory Forest Management (PFM) in improving the livelihoods of local communities and forest cover conservation in the Sagi-Tagata State Forest of Alle District. A cross-sectional design was used to capture the socioeconomic and livelihood status of participant households at a single point in time, while a longitudinal design was applied to assess forest cover change across 20 years (2003-2023) using satellite imagery.

The district was purposively selected due to its long-standing experience with PFM and the presence of well-established Forest User Cooperatives (FUCs). Four cooperatives, Abdi Bori Tageta, Abdi Gudina, Alle Tokuma, and Salen Wangus, were randomly selected from among the existing ones. A list of households in each cooperative was obtained, and systematic random sampling was used to proportionally select a total of 284 households out of a population of 979, based on the [23] sample size determination formula. Primary data were collected through structured household

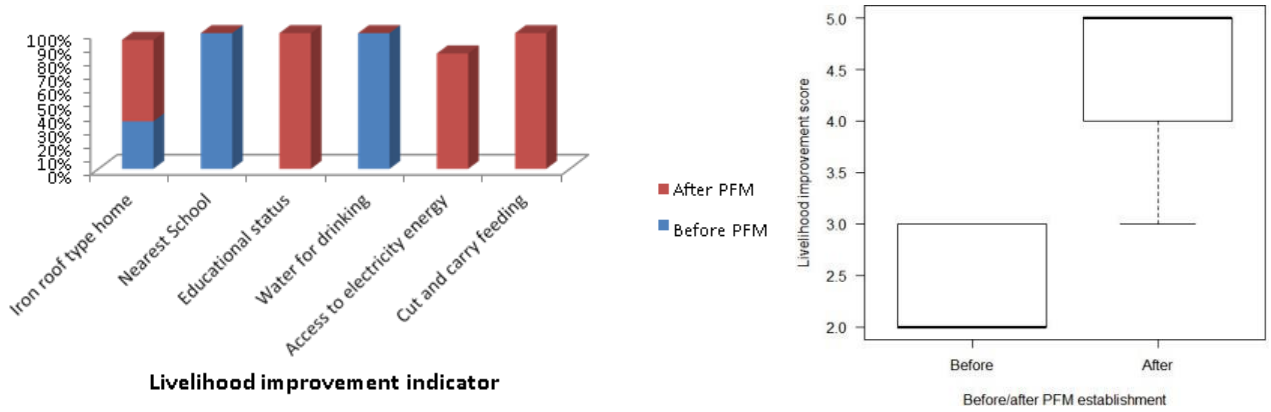
surveys, key informant interviews (KIIs), focus group discussions (FGDs), direct field observations, and satellite image analysis. For spatial analysis, Landsat satellite imagery from 2003, 2013, and 2023 was sourced from the United States Geological Survey (USGS) [22]. Images were selected from the dry season (December to March) to ensure minimal cloud cover and enhance vegetation visibility. These images were used to assess long-term changes in forest cover under the PFM framework.

2.3. Method of Data Analysis

Quantitative data were analyzed using SPSS Version 24 and Microsoft Excel 2010 for descriptive statistics, means, and frequencies. The impact of PFM on livelihoods was assessed through Wilcoxon signed-rank tests comparing pre- and post-PFM livelihood scores. Income diversification was evaluated using one-way ANOVA and post hoc LSD tests. A binary logistic regression model was employed to identify the determinants of participation in PFM programs based on variables such as education, gender, age, landholding size, access to training and credit, and proximity to forest and market centers. Cloud-free Landsat images from 2003, 2013, and 2023 were acquired from the USGS website. Spectral bands from Landsat 5, 7, and 8 were processed in ArcGIS 10.2, including atmospheric correction and clipping using forest shape files [5, 6]. Unsupervised classification and NDVI analysis were performed to identify major land-cover types (closed forest, open forest, shrubland, and barren land) [17]. Supervised classification using the Maximum Likelihood Classifier (MLC) was applied to develop land-cover maps. Post-classification analysis determined land-cover change trajectories, including rates of forest-cover change and detection of areas classified as "recovered" or "declined."

3. Results and Discussion

The implementation of Participatory Forest Management (PFM) has had a notable positive impact on the well-being of Forest User Cooperative (FUC) participants (Figure 2). Approximately 60% of surveyed households reported having constructed homes with corrugated iron roofing, indicating improved housing conditions. Furthermore, all respondents acknowledged enhanced access to education since the introduction of PFM. Focus group discussions corroborated these findings, revealing that forest-related activities have become the primary source of income for many households. Owing to limited farmland and low agricultural productivity, households have increasingly relied on non-timber forest products (NTFPs) such as beekeeping, controlled hunting, and pasture sales. These income-generating activities have substantially contributed to household economic stability. The findings align with those of [20], who reported similar outcomes in Kenya, where increased household income under PFM frameworks enabled families to send all their children to school. Additionally, 85% of respondents in the present study reported gaining access to electricity and achieving better pasture productivity. The significance of these livelihood improvements was statistically confirmed using the Wilcoxon signed-rank test, with results illustrated in the box plot provided below, highlighting the measurable impact of PFM interventions on socioeconomic conditions.



A) Livelihood Indicator B) Box plot livelihood conditions before and after PFM

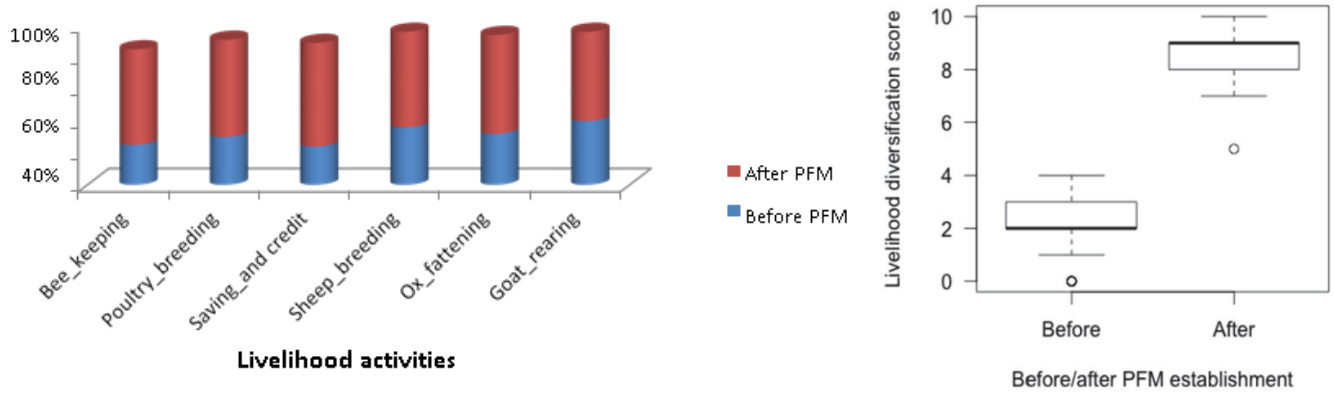
Figure 2. *Livelihood of the respondents before and after PFM implementation.*

The statistical analysis using the Wilcoxon signed-rank test demonstrated a highly significant difference in livelihood improvement scores between the periods before and after the implementation of Participatory Forest Management (PFM), with a p-value of 2.43e-24. These scores were calculated based on the cumulative effect of various improved livelihood indicators, such as access to Infrastructure, education, income, and housing. The test results confirm that membership in PFM significantly influenced household well-being, suggesting a measurable and positive change in livelihoods following PFM

adoption. This finding is consistent with the results of [16], who reported that PFM initiatives substantially enhanced community livelihoods by enabling sustainable resource use and creating alternative income opportunities. The evidence strongly supports the effectiveness of PFM as a strategy for improving rural livelihoods while simultaneously promoting forest conservation.

3.1. Effects of PFM on Livelihood Diversification

As shown in Figure 3a, the implementation of Participatory Forest Management (PFM) has significantly expanded the livelihood activities of participant households. Existing practices such as poultry breeding, sheep rearing, and ox fattening saw notable increases. For example, engagement in poultry breeding rose from 30% before PFM to 61% after its implementation, while sheep rearing increased from 36% to 60%, and ox fattening from 32% to 62%. Similarly, goat rearing rose from 40% to 56%. These findings suggest that PFM has not only introduced new livelihood opportunities but also strengthened existing ones. The Wilcoxon signed-rank test revealed a statistically significant increase in livelihood diversification scores following the implementation of Participatory Forest Management (PFM), with a p-value of 5.095e-16. This indicates that PFM membership has had a substantial positive impact on the diversification of household income-generating activities.



a) Livelihood diversification

b) Livelihood diversification score

Figure 3. *Diversification of livelihood activities for PFM households.*

3.2. Quantifying Forest Cover Changes Due to the PFM Program

Analysis of satellite imagery from 2003, 2013, and 2023 revealed notable changes in forest cover in the study area, corresponding to the implementation of the Participatory Forest Management (PFM) program. Before PFM, the area experienced significant deforestation and degradation, primarily driven by agricultural expansion and unsustainable forest resource extraction. However, following the introduction of PFM, the rate of forest loss slowed, and some areas showed signs of regeneration due to improved management practices and community engagement.

The classification results demonstrate a decrease in total forest cover from 89% in 2003 to 62% in 2023. However, the rate of degradation was slower during the post-PFM period than in the pre-PFM era. The establishment of forest user cooperatives and the enforcement of community-based forest protection measures fostered improved forest conditions and heightened awareness of sustainable resource utilization. These results align with various studies across different regions of Ethiopia, all reporting significant forestland conversion to alternative land uses throughout the 1990s [7, 18, 4, 14]. Similarly, [15] observed a trend of declining forest cover loss, with the rate falling from 11.2% in the initial period to 8.2% later. Consequently, the annual rate of forest cover loss also decreased from 0.4% to 0.2%. These trends reinforce the study's conclusion that PFM implementation has played a role in lessening the rate of forest degradation over time. Although challenges persist, these findings indicate that the PFM approach has been beneficial in reducing forest degradation and enhancing conservation efforts within the Sagi-Tagata State Forest.

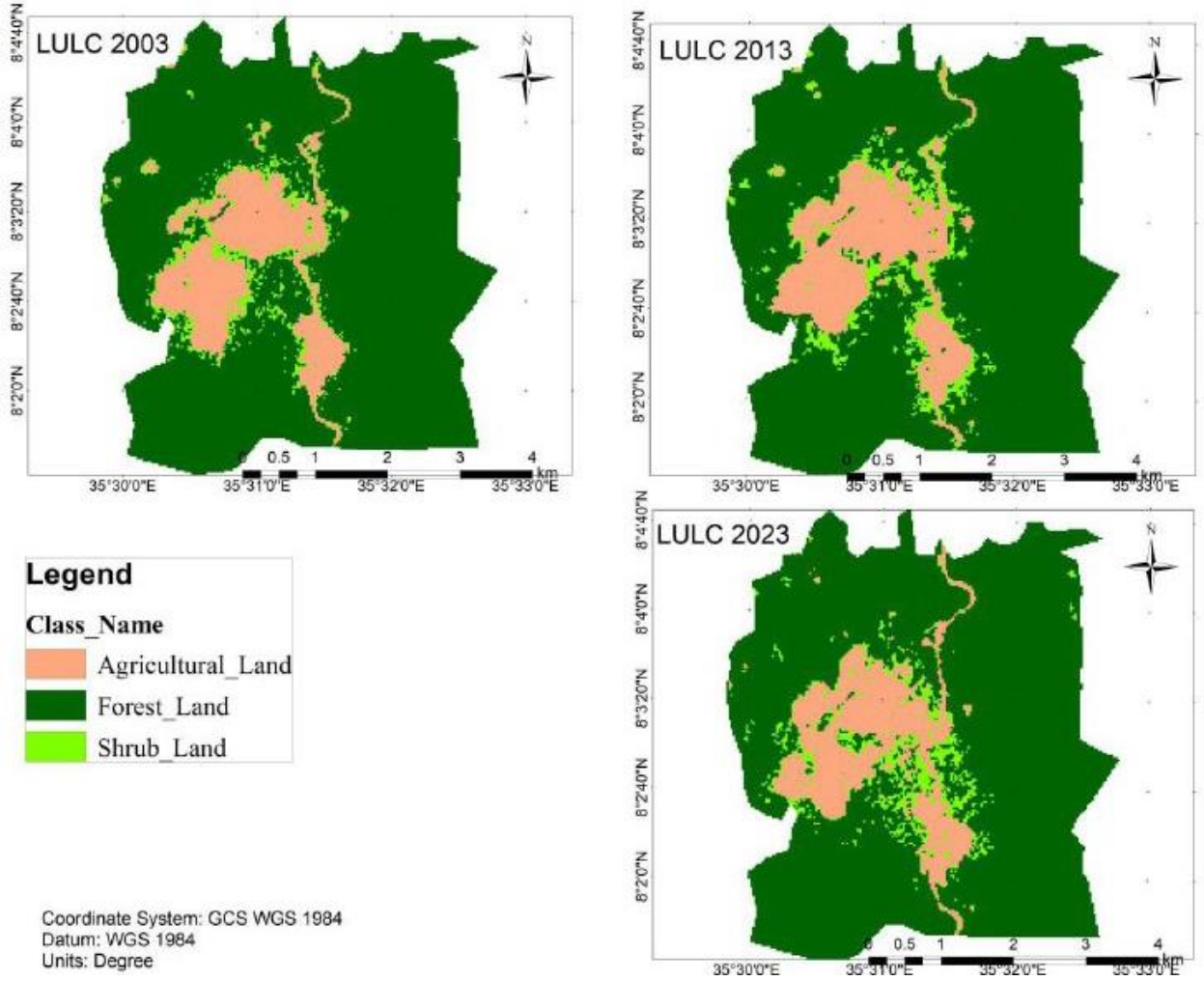


Figure 4. *Land use/land cover classification maps of the study area for the years 2003, 2013, and 2023, showing trends in forest, shrubland, cropland, and bare land distribution. The data illustrate significant forest reduction and cropland expansion over two decades, with slower deforestation following PFM implementation.*

Land-Cover Change Trajectories: Land cover change analysis revealed dynamic inter-class conversions among forest, cropland, shrubland, and bare land across both study periods. During the first period, 5% (149 ha) of closed forest was converted to cropland, shrubland, and barren land. In the second period, this conversion increased significantly to 22% (568 ha). Additionally, shrubland and cropland experienced interchanges, with shrubland decreasing by 0.5% (9 ha) and cropland increasing by 15% (158 ha). These transitions, detailed in Tables 1, 2 & 3, highlight both losses and gains in land cover, with diagonal values showing unchanged classes.

This pattern aligns with [15], who reported declining forest cover in both periods in Kenya's Lembus Forest due to similar inter-class exchanges. The annual rate of forest loss increased from 5% in the first period to 22% in the second, largely driven by a lack of reforestation following clear-cutting. However, the findings contrast with those of [21], whose study on the Bonga Forest concluded that forest management has a positive contribution to both conservation and sustainable use.

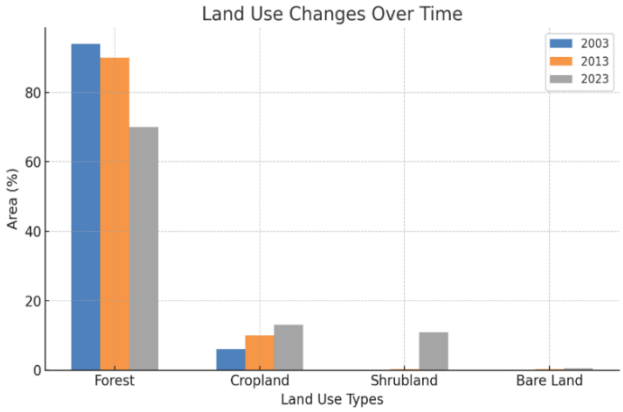


Figure 5. *Time series Land use change of 2002, 2012, and 2022.*

Table 1 highlights significant variations in annual land-cover change rates across the two periods. Closed forest

declined by 5% annually in the first period and by 22% in the second. Cropland increased at 6% annually in the first period and 4% in the second. Shrubland decreased by 0.4% initially but rose sharply by 17.5% annually in the second period. Barren land slightly declined by 0.4% in the first period and then increased by 0.5%. These trends align with [15], who observed similar forest cover declines in Kenya's Lembus Forest during both periods.

Table 1. *Change detection matrix from 2003- 2013.*

	2003 (ha)				
	Land use/cover types	**Forest**	**Cropland**	**shrub land**	**Bare land**	**Class Total**
2013(ha)	Forest	2164	43	25	38	2180
	Cropland	21	390	27	19	417
	Shrub land	14	36	13	24	27
	Bare land	8	22	15	8	23
	Class Total	2187	401	30	29	2576

Table 2. *Change detection matrix from 2013- 2023.*

	2013(ha)				
	Land use/cover Types	**Forest**	**Cropland**	**Shrub land**	**Bare land**	**Class Total**
2023(ha)	Forest	1596	13	15	28	1652
	Cropland	11	491	17	39	518
	Shrub land	24	36	469	44	573
	bare land	8	12	5	20	35
	Class Total	1639	542	496	101	2576

3.3. Forest-Cover Change Dynamics

The Sagi-Tagata area experienced dynamic land-cover changes characterized by both forest recovery (non-forest to forest) and forest decline (forest to non-forest). These changes occurred at varying temporal and spatial scales (Table 3).

Table 3. *Land use land cover change of Sagi-Tagata forest.*

Forest-Cover Changes	**First period (2003-2013)**		**Second Period (2013-2023)**		**Deviation in (ha)**
	Area (ha)	**%**	**Area (ha)**	**%**	
Forest	2164	84	1596	62	568
Cropland	390	15	491	19	101
Shrub land	13	0.5	469	18	456
bare land	8	0.3	20	0.8	12

3.4. Factors Affecting Participation in PFM

The binary logistic regression analysis identified several factors that significantly influence household participation in Participatory Forest Management (PFM). Key determinants include education level, access to credit, household size, landholding size, and proximity to forest resources. Households with better access to credit and training services were more likely to engage in PFM, as these resources improve their capacity to participate in forest-related activities and adopt alternative livelihood strategies.

Higher levels of education were positively associated with participation, likely due to increased awareness and understanding of PFM objectives and long-term benefits. Similarly, larger household and landholding sizes were linked to higher participation, possibly reflecting the greater resource needs and opportunities for diversification within these households. In contrast, households located farther from forest areas were less likely to participate, due to reduced dependency on forest products and limited access to PFM activities. These findings are consistent with previous studies. For instance, [19, 3] reported that education, credit access, and household size were significant predictors of PFM participation in Ethiopia. Likewise, [2] found that distance from forest, landholding size, and access to extension services significantly influenced community engagement in forest management. These alignments affirm that effective implementation of PFM requires targeted interventions to improve rural education, financial access, and institutional support.

Table 4. *Binary logistic regression analysis results of the determinants of PFM.*

T2-- test of variables							
		B	**S.E.**	**Wald**	**Df**	**Sig.**	**Exp(B)**
Step 1a	Sex	-1.482	.397	13.965	1	.000***	.227
	Marital status	-.883	.253	12.186	1	.285^{NS}	.413
	Level of education	-1.393	.352	15.667	1	.000**	.248
	Access to credit	-1.721	.362	22.597	1	.000**	.179
	Family size	-.194	.214	.821	1	.0.0138**	.824
	Landholding	.307	.185	2.749	1	.097*	1.359
	Livestock	-.594	.179	10.981	1	.001*	.552
	Forest Income	-.305	.233	1.720	1	.0027 **	.737
	Distance to the forest	-.114	.054	4.401	1	.036*	.893
	Constant	10.735	1.820	34.790	1	.000**	45915.413

Number of observations = 284 Wald chi2 (14) = 86.60
Prob > chi2 = 0.0000
Log likelihood = -53.675962
Pseudo R2 = 0.6294

4. Conclusion

This study demonstrated that Participatory Forest Management (PFM) has significantly enhanced rural livelihoods and decreased forest degradation in the Sagi-Tagata State Forest. Households involved in PFM saw measurable improvements in income diversity, housing quality, access to education, and livelihood security. While forest cover continued to decline over the 20 years, the rate of deforestation was markedly reduced following the implementation of PFM. Key factors that influenced participation included education level, access to credit and training, household and landholding sizes, and proximity to forest resources. Overall, the results highlight PFM's potential as an effective strategy for sustainable forest management and socio-economic development.

5. Recommendations

1) Enhance Access to Credit and Livelihood Training: Strengthen support services that enable rural households

to diversify their incomes through forest-compatible activities such as beekeeping, poultry farming, and NTFP harvesting. Access to credit and skills training can improve participation and economic returns from PFM.

2) Strengthen Institutional Capacity and Cooperative Governance: Invest in the technical and organizational capacity of forest-user cooperatives and local institutions to manage resources effectively. Clear benefit-sharing mechanisms, accountability, and community engagement are essential for sustainable outcomes.
3) Expand and Replicate PFM in Similar Forest Areas: Scale up successful PFM practices to other forest-dependent regions of Ethiopia, especially those experiencing high deforestation. Lessons learned from Sagi-Tagata can inform national strategies for community-based forest management.
4) Support Policy Integration and Coordination: Ensure that national and regional forest policies explicitly support community-based forest management models like PFM. Better alignment between forest governance, rural development, and land-use planning policies can foster long-term success and institutional support.

Abbreviations

ADANRO	Alle District Agriculture and Natural Resource Office
CSA	Central Statistical Agency
EEFRI	Ethiopian Environment and Forest Research Institute
EC	Ethiopian Calendar
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FUC	Forest User Cooperatives
KII	Key Informant Interview
LULCC	Land Use Land Cover Change
MLC	Maximum Likelihood Classifier
NDVI	Normalized Difference Vegetation Index
NTFP	Non-Timber Forest Product
PFM	Participatory Forest Management
SNNPR	Southern Nations, Nationalities, and Peoples' Region
SPSS	Statistical Package for the Social Sciences
USGS	United States Geological Survey

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Conflicts of Interest

The author declares no conflicts of interest.

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