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Does Participatory Forest Management Reduce Deforestation and Enhance Forest Cover? A Comparative Study of Selected Forest Sites in Adaba-Dodola, Ethiopia

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Abstract: Although extensive interventions are being made to protect forests, many developing countries, including Ethiopia, face persistent forest conservation challenges, particularly where local communities heavily rely on forests for their livelihoods. Recognizing the urgency of this issue, the government of Ethiopia introduced Participatory Forest Management (PFM) and devolved forest management responsibilities to enhance forest conservation. Therefore, investigating the impacts of PFM on forest covers is important. To this end, our research is based on an analysis of the land use/land cover changes (LULCCs) over the last 23 years in selected forest sites of Adaba–Dodola and their implications for the implementation of REDD+. This study examines the difference in forest cover changes between PFM and non-PFM sites within and between the study periods. Landsat images from 2000, 2012, and 2023 were analysed to detect LULCCs. Overall, the results from the comparison analysis indicate that in the period of 2000–2023, forest lands decreased by 5.22% in non-PFM sites, while they increased by 5.89% in PFM sites. On the other hand, agricultural lands experienced a notable increase of 9.64% in non-PFM sites but decreased by 1.65% in PFM sites. The increase in the forest cover is attributed to the effectiveness of PFM in halting deforestation and promoting forest conservation compared to non-PFM sites. Thus, the PFM approach is a tool for preserving forest ecosystems and mitigating the adverse effects of deforestation and forest degradation; therefore, this strategy could be used as a driving wheel for the implementation of REDD+.

Keywords: community forest; deforestation; change detection; land use/land cover; REDD+

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1. Introduction

In spite of intensive global efforts to protect forest resources, deforestation remains high, particularly in countries where rural communities heavily rely on forest resources to sustain livelihoods [1,2]. The urgency of addressing deforestation is underscored by the fact that tropical forests, with rich biodiversity, face threats from factors, such as global warming and land-use changes [3]. According to FAO and UNEP [4], forest degradation contributes to the loss of biodiversity, and it also occurs at a higher rate worldwide. It is estimated that the deforestation rate was about 10 million hectares per annum from 2015 to 2020. In the context of Ethiopia, deforestation rates are also high, with an estimated net loss of about 73,000 hectares per annum during the same period [5]. Multiple factors contribute to forest destruction in Ethiopia, including a high population growth rate, a growing need for agricultural land and construction wood and firewood, political instability, wildfires, insecurity of land ownership, insufficient conservation initiatives, and a lack of awareness about conservation [3,6,7]. Recognizing the severity of this situation, various forest management approaches have been developed and implemented, and large amounts of funds have been invested, aiming to improve local forest management to curb deforestation [8,9]. Forest management approaches and related legal and policy frameworks play a crucial role in shaping the conditions of forests, as they are key factors that greatly influence forest-related activities. However, the effectiveness of forest management approaches can be influenced by social, cultural, political, and economic conditions [1,8]. The purpose of forest management approaches varies based on local forest use and livelihood mechanisms, highlighting the need for context-specific strategies and evaluation methods [1].

PFM refers to a collaborative management that devolves forest management responsibilities and user rights to communities living adjacent to forests [10]. In Ethiopia, PFM was introduced in the 1990s as a new forest management system, and it was implemented as a pilot project, primarily by non-governmental organizations, aiming to promote sustainable forest management (SFM) [11]. Since then, this approach has expanded to cover an increasing number of hectares of forests across the country [10]. Lemenih and Kassa [12] indicated that about 1.5 million ha of forests were under the PFM program in the country. However, assessing the status of forest cover changes is essential for better conservation analyses and for providing sound decisions and reliable information regarding forest management systems [1,7]. Thus, more empirical studies, especially those that use remote sensing data to examine the impact of different management approaches on forest cover changes, are crucial. In Ethiopia, there are many studies on the LULCC of varying forest types under different management strategies [13–16]. However, our study aims to empirically compare two forest management approaches and their impacts on forest cover and other land cover changes. This study used forest sites managed by the community through PFM and the forest sites owned and protected by state-based enterprises through a non-PFM approach. Therefore, this study helps to understand the impacts of different approaches on forest sustainability.

Studies conducted in the past offer contradicting research outputs on the effectiveness of PFM on forest conditions. For example, Refs. [17–21] demonstrated that PFM has improved forest conditions and has reduced forest disturbance. Other studies, like that of Persha and Meshack [22], reported no significant difference between PFM and non-PFM forests regarding deforestation rates during 2000–2012 in Tanzania. Nigatu et al. [23] indicated that PFM facilitated forest degradation in the Bale Mountains Eco-region due to the expansion of cash crop farming. To provide additional results that minimize the gap in the relevant literature, this study aimed to examine the effectiveness of PFM in mitigating deforestation and enhancing forest conservation in the Adaba–Dodola forest in Southern Ethiopia over the past 23 years. This study analysed forest cover changes of PFM and non-PFM forest areas from the time PFM started implementation activities (2000) to the time of this assessment (2023) to provide insights on the extent to which PFM contributes to the effort of addressing deforestation.

2. Materials and Methods

The Adaba–Dodola forest (Figure 1) is located in the Adaba and Dodola districts on the northern slopes of the Bale Eco-region in the southeastern highland of Ethiopia. It is bordered by vast agricultural plains (more than 2000 km^2), located at altitudes of about 2400 m, and surrounded by mountain ranges. Almost all PFM and the non-PFM forest patches are situated on steep slopes and the edges of the mountains [14]. The livelihoods in the area depend mainly on subsistence crop production (predominantly wheat and barley), forestry, and livestock production. The main forest products harvested are fuelwood and charcoal, grasses and tree leaves as fodder, and timber for construction. The forest size has progressively reduced from 140,000 ha in the early 1980s to 53,000 ha in 1997 due to small-scale agricultural expansion, illegal settlements, and the over-extraction of forest resources [19,24]. The forest area was officially recognized as a state forest in 1975 during land reforms, and in 1998, it was identified as one of the National Forest Priority Areas (NFPAs). The nature of the vegetation is dry Afromontane, which is mainly composed of *Podocarpus falcatus*, *Juniperus procera*, *Hagenia abyssinica*, *Rapanea melanophloeos*, *Hypericum lanceolatum*, *Maytenus addat*, and *Allophylus abyssinicus* [21,25].

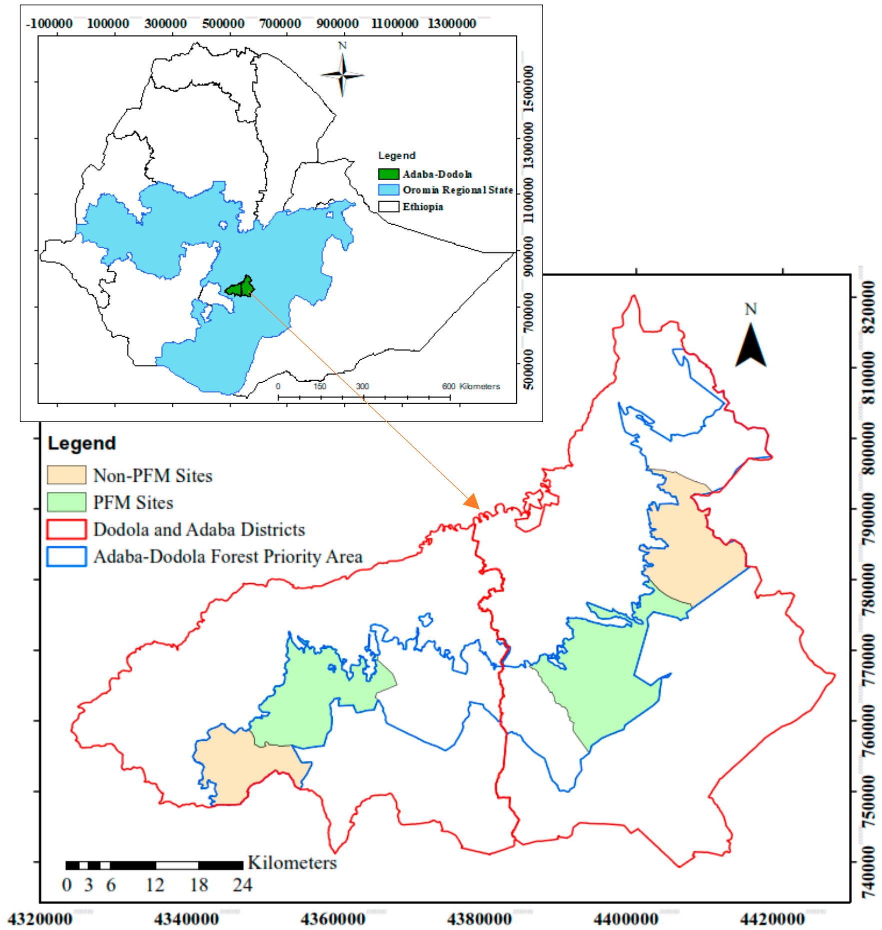

Figure 1. Map of the study area of the Adaba–Dodola forest.

In Adaba–Dodola, PFM began at the end of the 1990s as a pilot project with the major goal of organizing the local community into a forest dwellers' association officially recognized as WAJIB. WAJIB was approved in 2000 by the Oromia regional government. WAJIB is an acronym by the local language (Afan Oromo) meaning "forest dwellers' association". Members of the forest user group (FUG) were allowed to reside in the forest, graze their livestock in the forest, and harvest forest products. The income from the sales of timber extracted from natural forests is not shared with the government. The maximum size of members in one group was set to be 30, and each member handed over 12 ha of forest areas. The members are given the right to sustainably manage and use forest products with an allowable cut of less than 10% and to protect the forest by restricting the forest from illegal settlements, agricultural expansions, and incursion by others [14]. The FUGs were entitled to manage more than 47,000 ha of the forest priority area, while the other part is still controlled and owned by the state [24,25]. This forest area was selected as the case area, because it was a PFM pioneer in Ethiopia, and it borders the non-PFM forest still controlled by state-based enterprises, thus making a comparison possible. Before the establishment of PFM in Adaba–Dodola, both areas, considered as PFM and non-PFM for this study, have been a part of the state forest since 1975 and are controlled by the government. During sampling of the PFM and non-PFM sites, the researchers considered the similar landscape condition, socio-economic characteristics, and the forest areas adjacent to each other (Figure 1).

This study examined the differences in LULCC within and between 2000, 2012, and 2023 for two PFM sites and two non-PFM sites (Figure 1). The year 2000 was selected as a base year, because PFM was introduced in the 1990s and started on-ground implementation activities in Ethiopia, specifically in the Adaba–Dodola forest sites, in 2000 [24]. The year 2012 was chosen, because the government of Ethiopia launched a Climate Resilient Green Economy (CRGE) strategy in 2011 and started implementation activities by giving serious attention to forest protection and the rehabilitation of degraded areas. The year 2023 was when the data were collected; therefore, we aimed to examine the current status of this forest.

2.1. Image Pre-Processing and Processing

Landsat Enhanced Thematic Mapper Plus (ETM+) and Landsat Operational Land Imager (OLI) 8 with a spatial resolution of 30 m and a cloud cover of less than 5% were used to analyse land use/land cover changes in the area. Free Landsat satellite images of the same season, which are geo-referenced and radiometrically corrected, were downloaded from the United States Geological Survey (USGS) website (http://www.usgs.gov, accessed on 12 May 2023). Seasonal variation is one of the factors that could affect image selection because of the high cloud coverage and high amount of water vapor in the atmosphere during the rainy season. However, images captured during the dry season (mostly December to March) are usually cloud-free and offer better contrasts [26]. Therefore, the acquisition dates of the satellite images for this study slightly varied (between 4 February and 6 February). Landsat ETM+ SLC-off error was corrected by the Arc toolbox extension. The images presented in Table 1 were the images that were downloaded and used for this study.

Table 1. Detailed description of the images used for this study.

No.	Sensor	Pixel Resolution	Path and Row	Date of Acquisition
1	Landsat ETM+	30 m	168 and 055	5 February 2000
2	Landsat ETM+	30 m	168 and 055	6 February 2012
3	Landsat 8 OLI	30 m	168 and 055	4 February 2023

Five land use/land cover (LULC) categories were identified, i.e., forest lands, shrubs and bush lands, agricultural lands, grasslands, and barren and settlement lands (Table 2). These land uses were identified based on prior knowledge and a brief reconnaissance survey in the study area. The forest boundaries and areas of different forest sites were delineated by shape files collected from the Oromia Forest and Wildlife Enterprise (OFWE). GPS datasets were collected during a field survey for each identified LULC class (50 GPS points for each) for training and validation [6,27]. Accuracy assessments were made by using 30% of the collected ground control points. Secondary data, Google Earth images, and local knowledge of forest user groups were utilized to generate training and to validate historical satellite images from 2000 and 2012 [2,26]. The actual classification was carried out by supervised classifications using a maximum likelihood algorithm. Based on their spectral characteristics and ability to capture different landscapes including vegetation health and density, we used a combination of bands 5, 4, and 3 for Landsat ETM+ and bands 6, 5, and 4 for Landsat 8 OLI. The satellite images were processed using ERDAS Imagine 2015 and the ArcGIS 10.4 software. To ensure the consistency between datasets, all satellite images were projected to the UTM map Projection System, Zone 37N, and the Datum of the World Geodetic System (WGS84) [2].

As the focus of this study was on examining the impact of management approaches on forest cover changes, the forest land cover was further focused on. Accordingly, the class name forest lands and shrub lands were considered as forest cover categories, and others were categorized as non-forests (agricultural lands, grasslands, barren lands, and settlements). This study developed and applied the following flowchart of analysis to determine the forest cover dynamics in the study area (Figure 2).

Table 2. Descriptions of the land cover classes.

No.	LULC Type	Description
1	Forest lands	Lands covering at least 0.5 ha, covered by dense natural forests, open woodlands, moist mountain forests, plantations, or riverine forests, and attaining a height of at least 2 m and a canopy cover of at least 20% [28].
2	Shrub lands	Areas dominated by shrubs, defined here as woody vegetation generally less than 3 m tall, and if they are left alone long enough, shrub lands may become forest lands [29].
3	Agricultural lands	Areas under crops and fallow lands. Since the rural settlements are scattered and are close to cultivated lands, croplands and rural settlements were classified together [30].
4	Grasslands	Lands covered with the natural growth of graminea and herbaceous vegetation or lands sown with introduced grass and leguminous for the grazing of livestock [28,31].
5	Barren lands and settlements	Areas with little or no vegetation cover that consist of barren eroded landscapes and or exposed rocks and areas that are dominated by the presence of towns, residential areas, roads, hotels, and campsites [31–33].

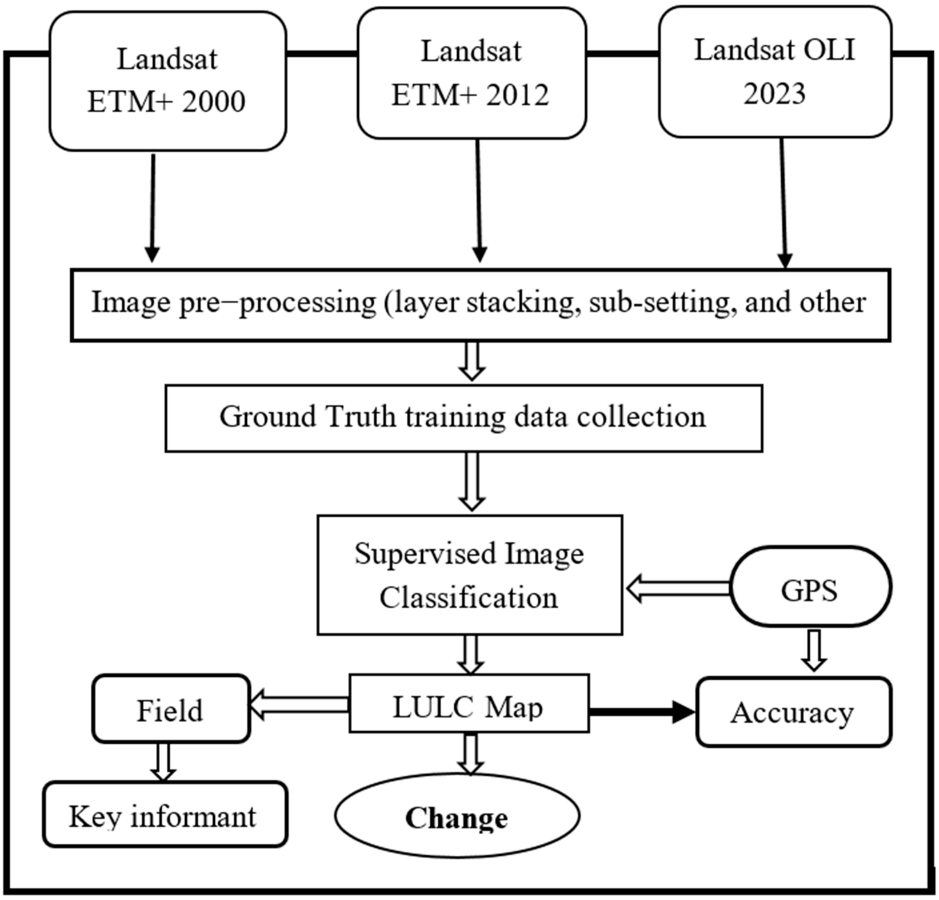

Figure 2. Flow diagram of the approach used to classify LULC of the study area.

2.2. Post-Classification Processing

2.2.1. Accuracy Assessment

An assessment of the classification accuracy of the 2000, 2012, and 2023 images was carried out to determine the quality of information derived from the data. As the purpose of such classifications is to also conduct change detection analyses, performing an accuracy assessment for individual classes is essential [26]. Accuracy was determined by comparing ground-truthing samples collected from field observations, Google map images, secondary data, and interviews with elders and classified images [6,34]. The assessment was carried out statistically using error matrices and was determined using the overall accuracy and users' accuracy assessments. To measure an agreement between predefined producer ratings and user-assigned ratings, the extent of accuracy for the various land-use types was determined by a non-parametric kappa assessment [1,27]. The criteria for the agreement of the kappa coefficient statistics were considered not good if kappa was < 0.4, good if kappa was <0.75, and excellent if kappa was >0.75 [35]. As a result, the assessed kappa coefficient showed strong agreement and was accepted for further analysis with the classified images of the 2000, 2012, and 2023 land cover maps.

2.2.2. Change Detection

After classification, an image comparison algorithm was used to determine the changes observed and the transition between different land use/land cover classes. This technique provides "from–to" change class information during 2000–2012, 2012–2023, and 2000–2023. The transition matrix was computed using ArcGIS 10.4.

2.3. Socio-Economic Data Collection

Remotely sensed data cannot fully explain why and how changes are happening. Therefore, it is essential to use socio-economic information [36]. Thus, socio-economic data were collected by using key informant interviews (KIIs) and focus group discussions (FGDs). A total of 20 key informants were selected by the snowball method from elders who had detailed knowledge about the LULC history in the study site. Focus group discussions were also conducted in four villages with community representatives from forest user cooperative committee members, local elders, women representatives, and youth representatives (one FGD per study site). Data from both the KIIs and FGDs were analysed using the content analysis method to identify why and how the LULC changes happened.

3. Results

3.1. Classification Accuracy

Table 3 indicates that the classification had an overall accuracy of 92%, with a kappa coefficient value of 0.86 attained for the 2000 classified map; 82% (with a kappa coefficient value of 0.76) for 2012; and 89% (with a kappa coefficient value of 0.83) for the year 2023. The user's accuracy in each LULC class ranged from 77% (grasslands and floodplains) to 96.9% (shrubs and bush lands). Based on the work by Congalton and Green [37], the kappa coefficient values indicate strong agreement between the ground-truth and the classified classes. Hence, the classified maps met the minimum accuracy requirements.

Table 3. Accuracy assessment results.

No.	LULC Classes	User's (UA) and Producer's (PA) Accuracy					
		2000		2012		2023	
		UA	PA	UA	PA	UA	PA
1	Forest lands	0.92	100	0.91	100	0.89	100
2	Shrubs and bush lands	0.97	0.88	0.8	0.83	0.86	0.98
3	Agricultural lands	0.89	0.79	0.81	0.82	0.9	0.86
4	Grasslands and floodplains	0.95	0.85	0.77	0.78	0.93	0.84
5	Barren lands and settlements	0.91	0.86	0.83	0.8	0.88	0.86
Overall classification accuracy		0.92		0.82		0.89	
Overall kappa statistics		0.86		0.76		0.83	

3.2. Comparison of LULC Trends Between Non-PFM and PFM Forests

To assess the impact of PFM in terms of LULC changes, the forest areas handed over to the local community as a PFM and the adjacent forest still under the control of a stated-based enterprise were compared. The assumption is that the forests under PFM and non-PFM were once a part of the state forests currently controlled by state-based enterprises. The sampled PFM and non-PFM forests are found adjacent to each other on similar landscape conditions along the hillside with similar exposures to physical and socio-economic forces. During 2000–2012, forest lands were reduced by 4.2% in non-PFM areas, while they increased by 2.1% in the PFM areas. However, during the same period, shrub lands increased by 3.66% in the non-PFM areas, while they reduced by 2.5% in the PFM areas (Tables 4 and 5). This means that forest lands reduced and shrub lands increased in the non-PFM areas due to an over-exploitation of forest products as a result of the forest management approach followed. During the second period of analysis, 2012–2023, forest lands reduced by 1% in non-PFM areas, while they increased by 3.8% in PFM areas. However, during the same period, shrub lands reduced by 5.2% and 0.6% in non-PFM and PFM areas, respectively. During 2000–2012, non-woody vegetated lands (agricultural lands, grasslands, and bare and built-up areas), on average, increased by 0.5% and 0.4% in non-PFM and PFM areas, respectively. But during 2012–2023, non-woody vegetated lands (agricultural lands, grasslands, and bare and built-up areas) on average increased by 6.2% in non-PFM areas while decreasing by 3.2% in PFM areas (Tables 4 and 5).

Table 4. Summary of non-PFM LULC changes (in ha and %) from 2000–2023.

No.	Non-PFM Land Cover Type	2000		2012		2023		LULC Gain or Loss in %	
		Area (Ha)	%	Area (Ha)	%	Area (Ha)	%	2000–2012	2012–2023
1	Forest lands	7931.2	32.5	6907.5	28.3	6655	27.2	−4.2	−1
2	Shrubs and bush lands	4966.2	20.3	5861	24	4594.3	18.8	3.7	−5.2
3	Agricultural lands	4264.8	17.5	4317	17.7	6619.7	27.1	0.2	9.4
4	Grasslands and floodplains	5027	20.6	5647.4	23.1	4396	18	2.5	−5.1
5	Barren lands and settlements	2247.5	9.2	1704.4	7	2172	9	−2.2	1.9
	Total area	24,436.5	100	24,437.3	100	24,436.7	100		

Table 5. Summary of PFM LULC changes (in ha and %) from 2000–2023.

No.	PFM Land Cover Type	2000		2012		2023		LULC Gain or Loss in %	
		Area (Ha)	%	Area (Ha)	%	Area (Ha)	%	2000–2012	2012–2023
1	Forest lands	13,164.6	34.8	13,965.4	37	15,395	40.6	2.1	3.8
2	Shrubs and bush lands	9163.8	24.2	8208.7	21.7	79,767	21.1	−2.5	−0.6
3	Agricultural lands	6380.27	16.84	7046.74	18.60	5754.09	15.19	1.8	−3.4
4	Grasslands and floodplains	5952.4	15.7	6156.3	16.3	7025	18.5	0.5	2.3
5	Barren lands and settlements	3224.7	8.5	2505.5	6.6	1732	4.6	−1.9	−2
	Total area	37,885.8	100	37,882.5	100	37,883	100		

A comparison of the two study sites during 2000–2023 revealed that the forest lands decreased by 5.2% in non-PFM sites and increased by about 6% in PFM sites. On the other hand, agricultural land increments were observed during the entire study period in non-PFM sites by 9.6%, while they decreased by 1.7% in PFM sites. The overall results of the study period (2000–2023) indicate that non-woody vegetated lands (agricultural lands, grasslands, and bare and built-up areas) increased on average by 6.8% in non-PFM areas while decreasing by 2.8% in PFM areas (Figure 3).

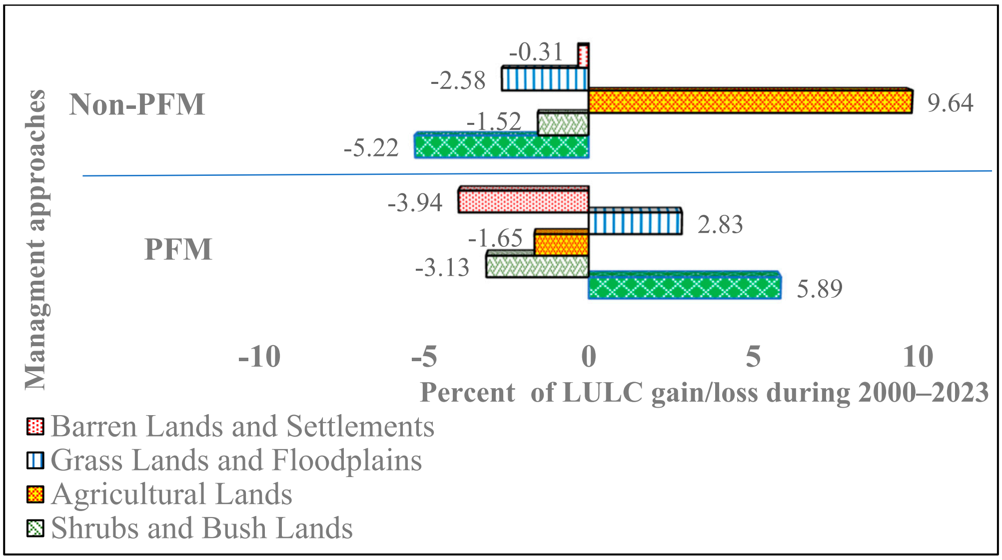

Figure 3. Percentage of gain or loss of each LULC in non-PFM and PFM areas during 2000–2023.

A total of five LULC classes and 12 maps (6 from Dodola and 6 from Adaba) were produced in the study area (Figures 4 and 5). The study period covers 2000, 2012, and 2023. Decreasing trends were observed in the forest cover of the non-PFM sites, while the forest cover shows an increasing trend in the PFM sites during 2000, 2012, and 2023. In the non-PFM sites, agricultural lands exhibited an increasing trend, while in PFM sites, they showed a decreasing trend during the study period (Figure 6).

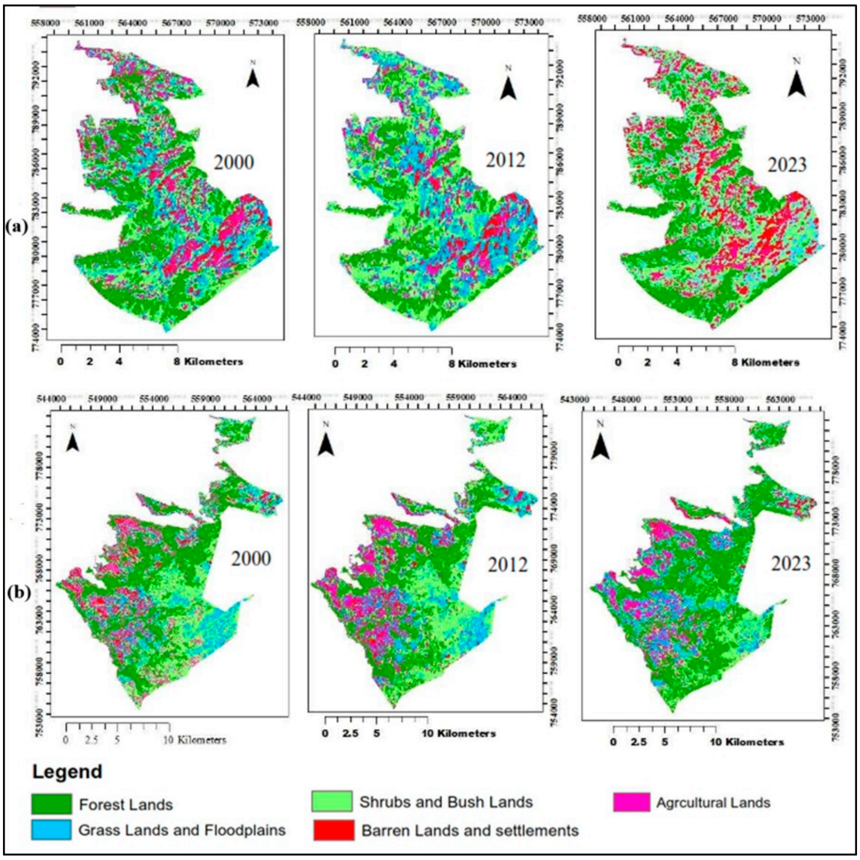

Figure 4. Classified land use/land cover maps of sample non-PFM (**a**) and PFM (**b**) sites from Adaba during 2000–2023.

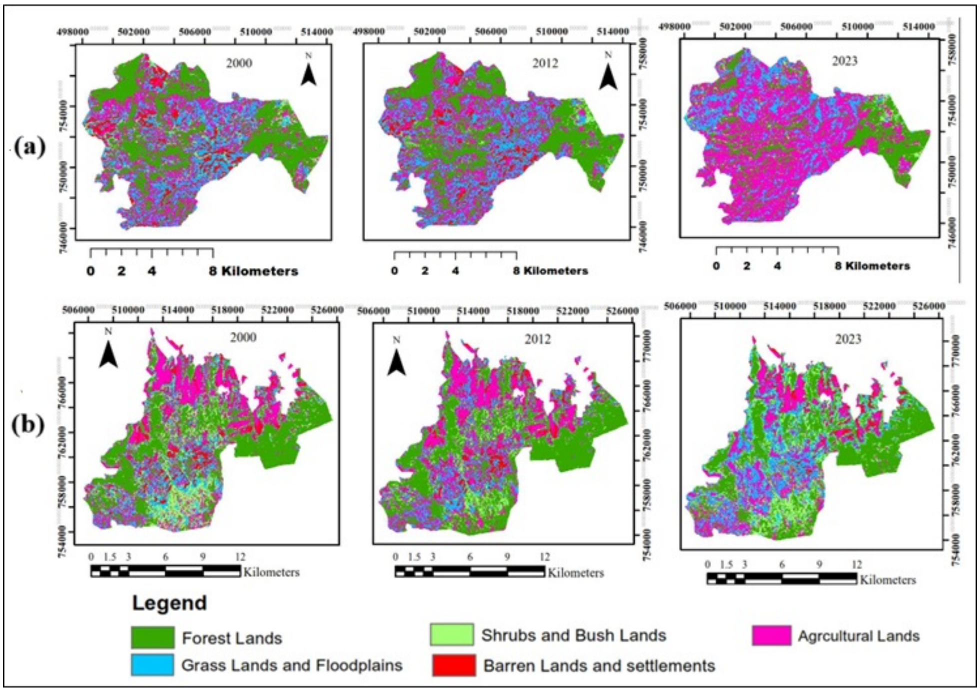

Figure 5. Classified land use/land cover maps of sample non-PFM (**a**) and PFM (**b**) sites from Dodola during 2000–2023.

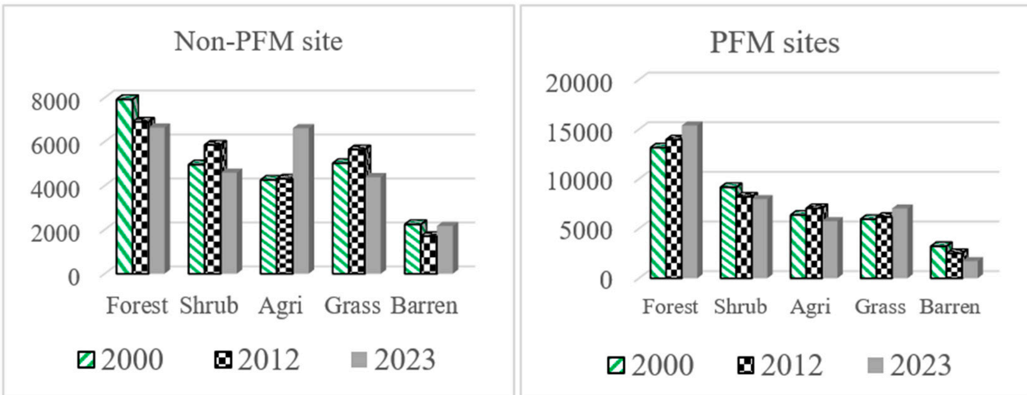

Figure 6. Trends of LULC types in non-PFM and PFM sites from Adaba–Dodola during 2000–2023.

3.3. LULC Change Detection of Non-PFM and PFM Forest Sites

Tables 6–9 present the change detection matrix of various LULC types of non-PFM and PFM sites in the study area from 2000 to 2023. Accordingly, the results show that about 59% of both non-PFM and PFM areas persisted, while about 41% of both sites changed in one way or another between 2000 and 2012 (Tables 6 and 8). However, between 2012 and 2023, about 49% of non-PFM and about 55% of PFM areas persisted, while about 51% of non-PFM and 45% of PFM sites changed in one way or another (Tables 7 and 9). These findings indicate that the non-PFM areas experienced more LULC changes over time than the PFM areas. The results from key informants also indicate that there were huge LULC changes in the non-PFM areas, because the local community considered this forest a state property. Therefore, they expand their agricultural lands in the forest, over-extract forest products, illegally settle within the boundaries of the forest, and over-graze their livestock within the non-PFM forest boundaries.

Table 6. Non-PFM areas' LULC conversion matrix from 2000–2012.

Non-PFM LULC Types 2000–2012	Forest	Shrub	Agri	Grass	Barren
Forest lands	5664.3	1588.9	541.8	124.1	4.8
Shrubs and bush lands	449.7	3018.5	594.5	856.4	39.8
Agricultural lands	723.4	428.8	1898.5	871.2	337.9
Grasslands and floodplains	55.4	674.7	926.7	2915.2	449.0
Barren lands and settlements	7.9	141.3	351.2	873.2	871.3

Table 7. Non-PFM areas' LULC conversion matrix from 2012–2023.

Non-PFM LULC Type 2012–2023	Forest	Shrub	Agri	Grass	Barren
Forest lands	4577.3	605.0	1448.5	246.4	23.7
Shrubs and bush lands	1803.9	2590.1	161.3	987.0	309.6
Agricultural lands	195.4	453.2	2527.1	807.1	328.7
Grasslands and floodplains	66.2	849.5	1926.7	1798.9	998.8
Barren lands and settlements	3.3	91.2	548.6	550.7	508.4

Table 8. PFM area's LULC conversion matrix from 2000–2012.

PFM LULC Types 2000–2012	Forest	Shrub	Agri	Grass	Barren
Forest lands	10391	2213	405	133	8
Shrubs and bush lands	1947	4593	1249	1308	58
Agricultural lands	1353	641	3036	671	668
Grasslands and floodplains	228	695	1410	3071	539
Barren lands and settlements	34	56	935	965	1229

Table 9. PFM area's LULC conversion matrix from 2012–2023.

PFM LULC Type 2012–2023	Forest	Shrub	Agri	Grass	Barren
Forest lands	10,836	2111	637	353	17
Shrubs and bush lands	4036	3291	182	630	58
Agricultural lands	333	1325	3025	1837	516
Grasslands and floodplains	152	1177	1141	3161	517
Barren land and settlements	21	64	760	1035	620

The results of this study indicate that the conversion of a forest area to other land uses was greater in the non-PFM areas than in the PFM ones, while the conversion from other LULCs to the forest cover was greater in the PFM than the non-PFM sites over the last 23 years (Figure 7). Results from the KIIs and FGDs reveal that after PFM's establishment, most of the degraded land was rehabilitated; shrub lands were protected to assist their conversion to forest lands; seedlings were planted on certain lands through community mobilization; and settlements were prohibited, except for forest dwellers living there before the establishment of PFM. These interventions jointly contributed to the conversion of other land covers to forests.

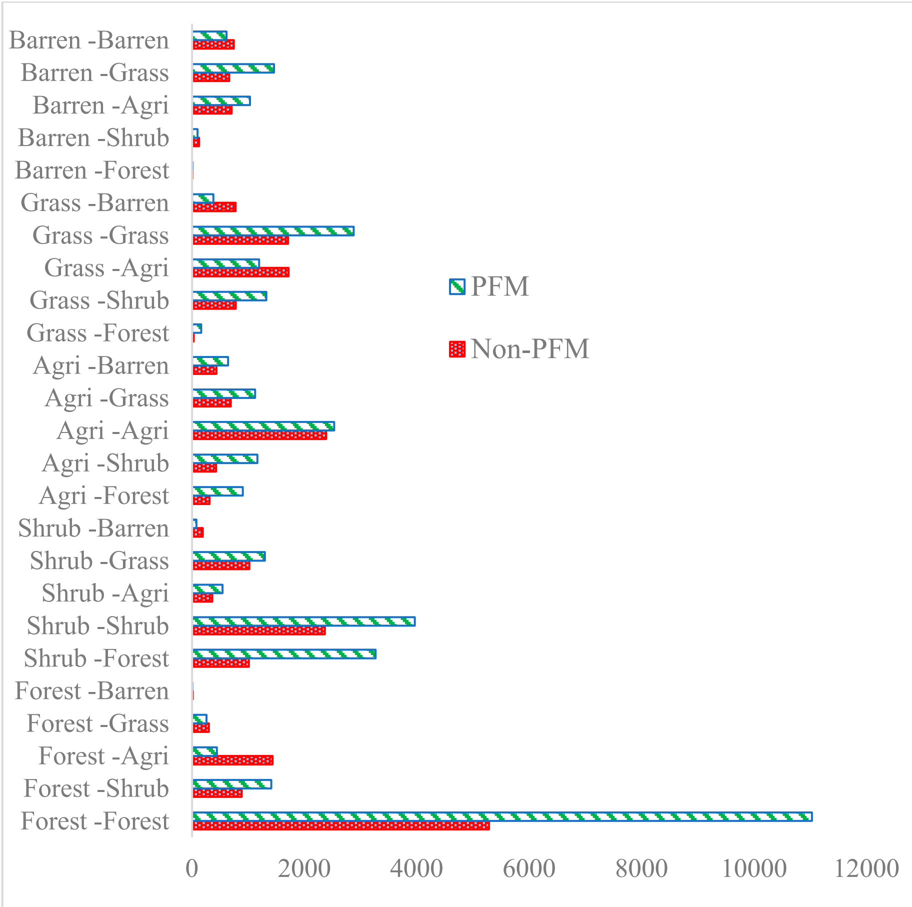

Figure 7. Land use and land cover conversion matrix of non-PFM and PFM areas from 2000–2023.

3.4. Community Perception of Forest Cover Changes and Major Causes

In addition to satellite imagery results, the perception of the local community from the KIIs and FGDs on different causes of LULC changes were analysed, and factors responsible for the increment and reduction in forests and other land covers were listed. All the participants of the KIIs and FGDs perceived that the forest status has improved in the PFM areas, while it is declining in non-PFM areas. Plantations on public lands through conservation programs, woodlot developments by individual farmers, enclosures of certain degraded forests, the prohibition of agriculture and settlements into forest lands, controlled grazing and wood extraction by forest user groups, and better forest law enforcement were recorded as reasons for forest improvements in the PFM sites. Illegal agricultural encroachments; illegal settlements; the illegal harvesting of timber, poles, and firewood; and frequent forest fires were recorded as reasons for reductions in the forest cover (Figure 8).

During field observations and discussions with local elders and experts, the latter elaborated that after the introduction of PFM, the forest dwellers association, government, and cooperative members prepared laws and regulations that would regulate illegal settlements, illegal wood extractions, and agricultural expansions within the forest boundaries, while promoting tree planting and forest restoration.

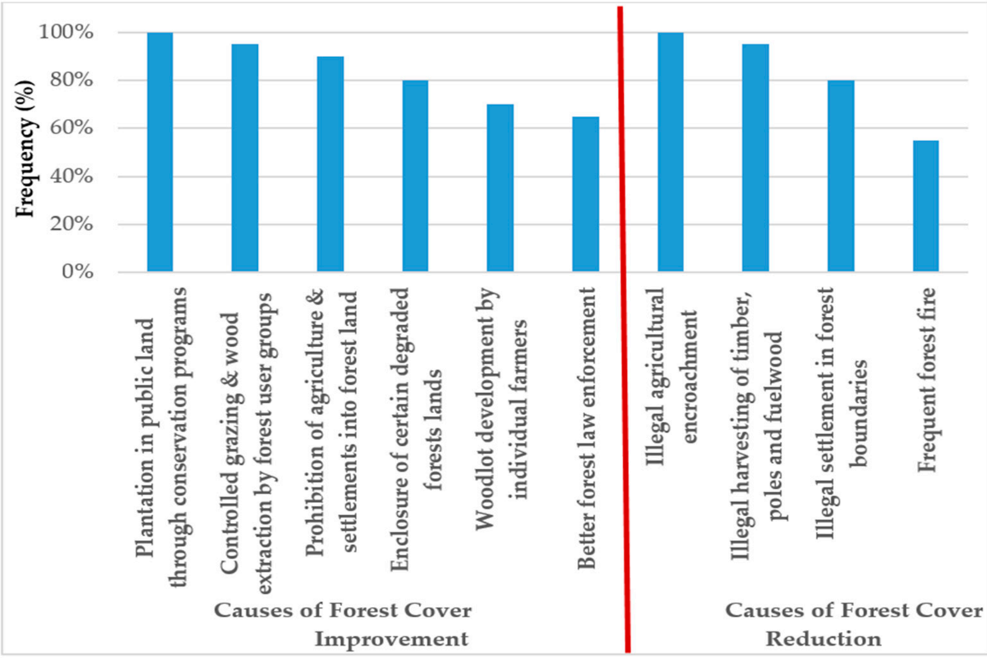

Figure 8. Major causes of forest cover changes in the Adaba–Dodola forest area.

4. Discussion

The objective of this study was to determine the impacts of PFM in maintaining and enhancing the forest cover compared to nearby non-PFM sites controlled by the state enterprises. Many studies have been conducted in Ethiopia on LULCCs of different forest types under different management approaches. However, there is a limited understanding of the impacts of PFM in maintaining the forest cover compared to the forest areas controlled by the government. Therefore, this study provides insights for forest managers, policymakers, and international organizations working on forests. The overall study results indicate that PFM has a positive effect on enhancing and maintaining forest covers.

4.1. Comparative Analysis of LULC Trends Between Non-PFM and PFM Sites

Comparing forest cover changes and deforestation rates between PFM and non-PFM areas is important to evaluate the degree of achievements in the community-based forest management of Adaba–Dodola for the last 23 years of operation. Generally, PFM has a higher potential to improve forest covers and to decrease deforestation than non-PFM forests. The response from the KIIs and FGDs also support the claim that forest lands reduced in the non-PFM areas due to the illegal harvesting of forest products and at the expense of illegal settlements and agricultural land expansions. Similarly, the results of the LULC change matrices of our study indicate that the conversion of a forest area to other land uses was greater in the non-PFM areas than the PFM ones, while the conversion from other LULCs to the forest cover was greater in the PFM areas over the last 23 years (Figure 8). Therefore, managing forests by local user groups and supporting organizations is one of the reasons for improved forest covers and reduced deforestation [36]. Communities inherited and developed ways of utilizing forests without affecting their futurity through their traditional beliefs and norms. However, the reluctance to give forest management and user rights to the local community externalizes forest-dependent communities, hence leading to the 'tragedy of the commons'.

The overall results of this study during the period of 2000–2023 indicate that forest lands decreased by 5.2% in non-PFM sites, while they increased by about 6% in the PFM sites. Furthermore, agricultural lands increased by 9.6% in the non-PFM sites and decreased by 1.7% in the PFM sites (Figure 3). A study conducted by [14] in a PFM forest in the Dodola district found that forest lands increased. Ray et al. [38] indicated that the total forest cover of a community-managed forest increased, while non-vegetated areas decreased in Bangladesh after PFM. KII respondents and FGD participants strongly highlighted that the shortage of agricultural lands due to high population growth rate in the study area has been a driving factor for agricultural land expansions into forest areas. If there is no active involvement of local people in forest management, it is also likely that they will exploit forest products like timber, poles, and fuel woods unsustainably. Also, illegal encroachments into forest areas become intense when local people are denied the right to manage and use the forest for their survival [39,40]. In the same vein, Kamoto et al. [41] determined that providing incentives and promoting behavioural changes are some of the contributing factors to reduced deforestation and forest degradation in PFM forest areas.

Our findings are also in line with studies that compared the performance of PFM and non-PFM areas in terms of forest cover changes and those that reported that PFM was more effective in reducing deforestation than non-PFM areas [36,42–45]. The reason for the reduction in the forest cover of non-PFM areas is related to illegal timber and pole harvesting, encroachments of agriculture and settlements, and uncontrolled fuel wood collection [14,36]. A study conducted in Thailand comparing PFM forests with national parks and national forests revealed that PFM forests performed better in maintaining their forest cover [45]. Singh et al. [46] also indicated that PFM forests had greater forest cover persistence than non-PFM ones. A study in Mexico on the effects of community forest management on deforestation identified that PFM forests have a significantly greater forest area than non-PFM ones after five years of adopting community-based forest management [47].

On the other hand, a study conducted in Malawi that compared both PFM and non-PFM forests indicated that the forest coverage has declined in both management approaches, but the forest loss was severe in non-PFM forests [48]. The reason behind this forest loss was limited knowledge of implementing forest management plans (e.g., determining and regulating allowable cuts) and a large demand for agricultural lands. Porter-Bolland et al. [49] analysed studies on protected areas and community-based forest areas through a systematic review and found that there is deforestation under both management types, but the average annual rate of deforestation was higher in protected areas than that of community forest areas. This means forests under PFM had a lower rate of deforestation than non-PFM ones; hence, PFM is the best approach to sustainably manage forest resources. Bowler et al. [50] also found, in their systematic review, that there is a mixed trend of forest cover changes from place to place after the implementation of PFM. These variations from place to place are based on the available legal and policy frameworks, the socio-economic characteristics of the local people, and the biophysical condition of the forest.

Another study conducted in Bangladesh by [51] indicates that this country's forest cover decreased after the establishment of PFM. This result contradicts that of our study, because the local community in Bangladesh competes for products from natural forests while managing plantation forests around their homestead through PFM. The annual forest loss of PFM forests in Bimbia–Bonadikombo of Cameroon showed an increasing trend due to the widespread prevalence of fuel wood harvesting, illegal timber, and land grabbing by companies, which occurred mostly by corrupted elites and public authorities [52]. Therefore, even though local and indigenous communities are better protectors of forests, simply devolving forest resource management to the local community is not enough without legal and policy frameworks, law enforcement capacities, and a recognition of the socio-economic development of the forest dependents. Further investigations of the effectiveness of forest governance in the Adaba–Dodola PFM forest are necessary.

4.2. Implications for REDD+

REDD+ is a mechanism through which developed countries provide financial incentives to developing countries as the developing countries keep their forests standing and obtain result-based payments for actions to reduce deforestation and forest degradation while investing in sustainable forest management [53]. The persistent problems of deforestation and forest degradation, biodiversity loss, and poverty problems should be solved to achieve REDD+ targets. Thus, an effective implementation of REDD+ needs strong political commitment, fewer drivers of deforestation and forest degradation, strong multi-level forest governance, and strong technical and administrative capacities [54–56]. According to the UN-REDD program report, deforestation and forest degradation contribute about 11% of all carbon emissions [57]. Curbing deforestation, forest degradation, and related emissions have been the core issues in Ethiopia's REDD+ strategy [58]. To address these core issues, reducing the drivers of deforestation and forest degradation was raised as an important factor of this strategy. A participatory process was adopted for the success of the implementation of this strategy of which the devolution of forest management to the local community receives greater priority in this strategy. Our study was conducted to address the issue of the effectiveness of PFM in reducing deforestation and improving forest covers for the future implementation of REDD+ by comparing non-PFM and PFM forests, with Adaba–Dodola being among the pioneering community forests of PFM in Ethiopia.

The results of our study show that PFM has had better results in reducing deforestation and improving the forest cover over the last 23 years. Therefore, PFM has a promising future for the implementation of REDD+. Given this situation, managing forests through PFM better addresses major drivers of deforestation than non-PFM strategies, which improves forest covers and halts deforestation. Overcoming deforestation through a common consensus with forest-dependent communities and Indigenous people is one of the core principles of the REDD+ safeguard document [57]. So, if REDD+ is linked to community forests, it can incentivize forest-dependent communities by acknowledging their efforts in sustainable forest management. However, when conducting the KIIs and FGDs, the forest-dependent communities complained about the lack of incentives to support the livelihoods of vulnerable community members whose livelihoods have been dependent on forest products. These vulnerable community members illegally extract forest products and encroach forest areas for settlement and agricultural practices. Despite these challenges, PFM has the potential to facilitate the successful implementation of REDD+ in Adaba–Dodola. However, it is important to specifically understand the relationship between forest-dependent community livelihoods and forest conservation.

5. Conclusions and Recommendations

In conclusion, gaining insights into the effects of different forest management options on land use/land cover types is important for deciding on future forest management. The findings of our study reveal that PFM provides effective protection against deforestation and promotes an increase in the forest cover of the study area. We observed an incremental trend in the forest cover within PFM areas, which contrasted with a decreasing trend in non-PFM areas over the study period. The forest cover gain of 0.3% per year in the PFM areas, while a loss of 0.2% per year over 23 years in the non-PFM areas, underscores the contribution of PFM to conservation efforts and is a good indicator of PFM's ability to maintain and improve forest covers. Moreover, the significant expansion of subsistence agricultural lands by 9.6% into non-PFM forest areas over 23 years is evidences the claim that PFM is a promising management approach for sustainable forest management. Based on these findings, we conclude that devolving forest management to community-based cooperatives is an effective option for reducing deforestation and enhancing forest conservation and climate change mitigation. This study assumed the impact of leakage as a constant factor, and the lack of consideration for the displacement of forest use would be one of the limitations of this study. Additional investigations are needed to explore aspects of forest governance, leakage, biodiversity conservation, and livelihood impacts within the context of participatory management in this study area. Furthermore, future research should contribute to a more comprehensive understanding of the implications of PFM and should inform evidence-based decision making in forest management practices for the effective implementation of REDD+.

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manuscript. J.M.A., K.M. and M.T. supervised the writing of the manuscript by providing significant input. All authors have read and agreed to the published version of the manuscript.

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