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Forest cover loss and recovery in an East African remnant forest area: Understanding its context and drivers for conservation and sustainable ecosystem service provision

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ABSTRACT

Understanding of the often complex forest cover change drivers, and the perceived and observed forest cover changes substantially contributes to the sustainable management of tropical forests. This paper aims at developing an integrated view on tropical forest cover change and its drivers by combining the perception of the stakeholders (farmers, forest guards, and forest managers) and five decades forest cover mapping, based on interview and remote sensing respectively, through a case study in the central highlands of Ethiopia. Afforestation and deforestation occurred when law enforcement was stronger and weaker respectively, depending on political regimes. Since 1937 i.e., the early Imperial period, the position of the forest edge has not changed much over time, it rather became sharper. In the late Imperial era (1972–1975), the forest cover declined only by 1.6%. In the subsequent two governments, the socialist and the current federal rule (1975–2014), the forest cover increased by 17%. There was a 3.9% forest cover decline during the transition between the two governments. This pattern of overall net forest cover increase observed by remote sensing data has been correctly perceived by stakeholders. Stakeholders acknowledged the observed forest cover increase, however, they argued that the forest is declining in terms of its quality for several ecosystem services (ES). The ES decline is believed to have resulted from the gradual shift of pure dense indigenous forest to an increasing share of exotic plantations. In the three political regimes, land policy, illegal encroachments, population pressure and social unrest have been the leading drivers of forest cover change. Communities' involvement in forest management activities and sharing benefits were regarded as positive perception of forest management strategies during the federal administration (1993–2007) of the current government by farmers. Among the factors that determine forest management strategies proposed by stakeholders are gender, landholding size, education level and age. Future conservation and development interventions need to consider stakeholders' concerns. Their involvement in forest management is also necessary for improved biodiversity conservation, ecosystem service provision, and social wellbeing.

1. Introduction

Tropical forests contain at least two-thirds of the Earth's terrestrial biodiversity (Gardner et al., 2009), they also store about 40% of global terrestrial carbon (Beer, 2010), maintain indigenous cultures, and support the livelihoods of millions (Lowman, Burgess, & Burgess, 2006, p. 291). Increased rates of deforestation as well as forest degradation in and around these forests, however, are constantly eroding the biodiversity and thereby threatening the functioning of ecosystem services that are essential for human wellbeing. Finding a sustainable and balanced way between the tropical forest ecosystems and human activities is, therefore, a high priority on the agenda of environmental policy

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makers (Balmford, Beresford, Green, Naidoo, & Walpole, 2009). In this context, the installation of protected forest areas has played a crucial role in slowing down deforestation. Nevertheless, even within the protected East African forest reserves, the total forest cover area has been decreasing over the past decades (Green et al., 2013; Sassen, Sheil, Giller, & ter Braak, 2013) as a result of increasing demand for new land resources. This results in several recent estimates of local and national forest cover changes (Getahun, Van Rompaey, Van Turnhout, & Poesen, 2013) that seem to reveal that tropical deforestation rate remains unchanged regardless of several forest management interventions (Achard et al., 2002; Beer, 2010).

National forest policies are widely mentioned as a driver of forest cover change that plays a central role in both forest cover increase and decline in many tropical countries (Eliasch, 2008), but its exact role and impact on local forest governance remain debated (Southworth, Nagendra, & Munroe, 2006). For instance, forest policy implementations often aim at increasing forest biomass stocks, without distinguishing between natural and planted forests or reforests (Chazdon et al., 2016). Moreover, the need of stakeholders is not taken into consideration, while they are highly dependent on forests (Duguma, Hager, & Gruber, 2009). In this sense, forest quality in terms of its long term biodiversity conservation and related ES maintenance may become critical even though the forest standing stock is still adequate. In this respect, analyzing the roles of national forest policies in local forest governance could reveal important insights. Distinct forest policies have been implemented in the last five decades in Ethiopia by three different political regimes. During the Emperors' time, i.e. before 1974, land property rights were complex because land ownership could belong to private owners, communities the state, or the church (Young, 2006, p. 290). During the socialist military regime (1975–1989), all land use rights were awarded to peasants until the subsequent land reform of 1975, which nationalized all landholdings under the direct possession of the state (Stellmacher, 2007). Despite the differences in approach (the former used ‘divine right’ to legitimize its system of rule and the latter was guided by Marxist-Leninist ideology) both regimes governed through highly centralized power structure (Young, 1997). In 1995, the current rule i.e. “Ethiopian People's Revolutionary Democratic Front” (EPRDF) adopted a more decentralized federal policy (Young, 1997) and proclaimed agricultural intensification. The forest sector is believed to supplement the agricultural production for accelerated economic growth (Stellmacher, 2013). These land policy transitions have had significant implication for the development of forest policy, but not many studies looked into the effects of these policies and policy changes on forest cover and forest cover change. Therefore, more studies are needed to better understand the influence of national forest policies on local forest governance and forest cover change dynamics in East African countries.

In order to contribute to a better understanding of forest cover change and the role of policies on forest management systems, a study area, Menagesha Suba forest at 45 km west of Addis Ababa, Ethiopia was selected as a case study (Fig. 1). This study area was selected because: (1) this forest is one of the oldest conservation areas in Eastern Africa, (2) the area was subject to different forest management intervention policies during the last five decades that resulted in forest increase, degradation (reduction in quantity and/or quality of the forest's structure and function) and deforestation (the conversion of either indigenous or exotic forest into other land use such as pasture and croplands), and (3) the study area is under pressure of an increasing population and the expanding capital city.

The study addressed the following specific objectives:

1) To map forest cover change over the last five decades and to compare it with stakeholder perceptions on the change and its drivers. We relied on remote sensing data (high resolution satellite and aerial imagery) from the period 1972–2014 to quantify the observed forest cover change. We used questionnaires to capture stakeholders' (farmers, forest guards and forest managers) perceptions of indigenous forest (land predominantly covered by a relatively continuous cover of native tree species) cover change into other land use types such as exotic plantation (land covered by continuous cover of non-native tree species), pasture land, or farmland within the Menagesha Suba protected area, as well as its drivers. Stakeholders' perception on forest cover change are believed to complement the result of the observed forest cover change.
2) To understand the perception of farmers on forest management strategies implemented during three subsequent political regimes in the study area. Furthermore, to investigate forest management options proposed by farmers and social factors affecting the proposed management options. Age, gender, landholding size, household size, and education are considered to determine the proposed management strategies.

2. Materials and methods

2.1. Study area

The study area extends between 8° 53' - 9° 03′ N and 38° 28' - 38° 40′ E in the central highland of Ethiopia lying in an altitudinal range between 2200 and 3320 m a.s.l. (Fig. 1). Menagesha Suba forested land covers 35 km^2 within its former legal boundary (96 km^2) delineated in 1984. It is characterized by cereal dominated farmland with sparsely scattered woodlands. Menagesha Suba forest is the oldest preserved park in Africa, protected since the 16th century (MoA, 2002). Breitenbach and Koukol (1962) observed trees as old as 360 years. The forest is composed of two forest blocks: Menagesha (380 ha), a smaller block in the northeast, and Suba (3120 ha), a larger block in the southwest. Suba lies on the western slopes of the large extinct Wochecha volcano while Menagesha occupies a smaller volcanic cone. The Menagesha Suba forest is classified as upland dry evergreen forest (Friis, 1992). The vegetation distribution follows altitudinal variation ranging from high forest on the lower altitudes to afro-alpine vegetation at higher altitudes. The Juniperus-Olea forest belt with presence of Afrocarpus reaches 3000 m a.s.l. The plantation part of the forest consists of Eucalypt, Pine, and Cypress trees. The area enjoys the presence of various larger mammal species such as Menelik bush-buck, colobus monkey, baboon, duiker, leopard, and serval (MoA, 2002).

The forest is surrounded by small towns and the rapidly expanding city Addis Ababa, where a considerable number of the population depends on biomass for fuelwood energy. This has led to lucrative markets, in most cases for illegally harvested wood from the forest (Bekele, 2003). In the 1991 count, there were 4216 households with a total population of over 23,500 in the seven peasant associations. Out of these, about 1426 households with a population of over 8000 resided within the demarcated area of the forest (MoA, 2002). There have been long-term social-ecological interactions between the forest and the local communities, which in the last three decades have been characterized by conflicts and illegal encroachments (Duguma et al., 2009). The communities in the area are agrarian and practice subsistence agriculture as well as small-scale woodlot and shrub planting (Duguma & Hager, 2010). Agricultural land productivity is low and the only source of forest products in the area is Menagesha Suba forest. Therefore, the communities are highly dependent on the forest for forest ecosystem services. For example, a study conducted by MoA (2002) shows that about 31% of the households that are located inside the forest boundary strongly rely on the forest for fuel wood, charcoal, and timber.

2.2. Mapping forest cover changes

Remote sensing imagery, aerial photographs, and field observations were the main data sources used for this research. Semi-structured interviews were used to complement the findings. To make an appropriate temporal selection of the imagery, major political, policy, and

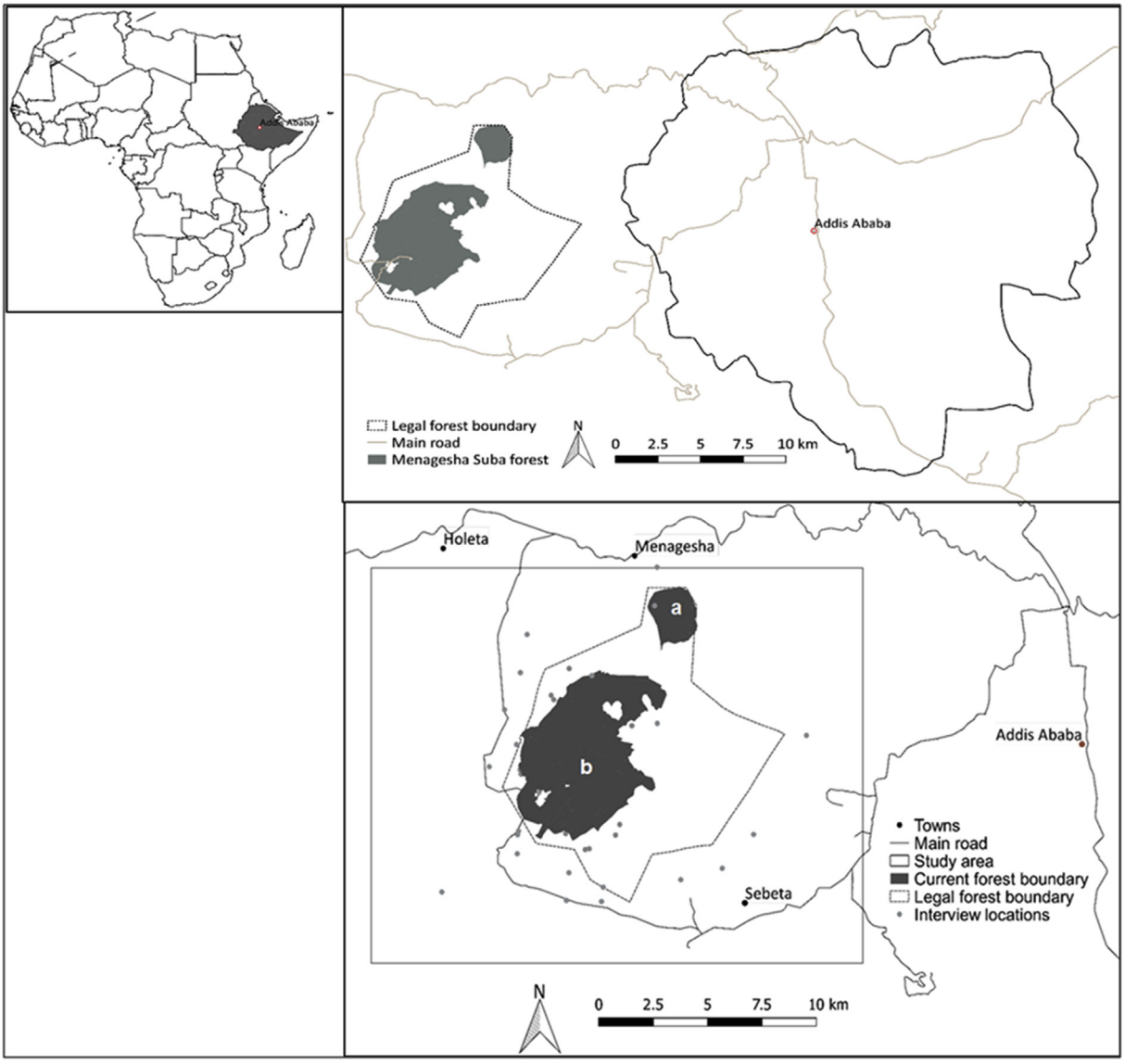

Fig. 1. Map of the study area in Ethiopia with two forest blocks, Menagesha (a) and Suba (b) and the distributions of interviewees' locations.

Table 1
Selected remote sensing images for forest cover change study and reason for their selection.

Years	Aerial imagery/ Satellite and sensor	Date of acquisition	Spatial Resolution	Reason for selection
1937	Aerial photo	1937		Early imperial era
1965	Aerial photo	1965	–	Middle imperial era
1971	Aerial photo	1971	–	Middle imperial era
1972	Landsat 1 MSS	12/26/1972	60 m	Late imperial era
1975	Landsat 2 MSS	10/27/1975	60 m	Late imperial era
1986	Landsat 5 TM	1/21/1986	60 m	The socialist era
1989	Landsat 4 MSS	11/29/1989	60 m	The socialist era
1994	Landsat 4 TM	3/21/1993	30 m	Transition from socialist to EPDRF
2011	Landsat 5 TM	1/10/2011	30 m	EPDRF
2014	Landsat 8 TIRS	1/08/2014	30 m	EPDRF

social changes were considered in consultation with the local communities. Particular attention was given to the 1974 government change, the 1975 land reform policy, and the 1991 government transition (Table 1). Aerial photographs of 1965 and 1971, which only cover the larger forest block of Suba were selected to assess the situation of forest cover during 1965–1971. The availability of aerial photographs of 1937 for a small area at the forest northern edge (Nyssen et al., 2015) made it possible to expand the analysis back in time. Moreover, Landsat images of 1972, 1975, 1986, 1989, 1993, 2011, and 2014 were used to investigate forest cover change during the past two i.e. the late imperial era (1972–75) and socialist era (1975–1989) and the current government (1993 inwards) in Ethiopia. The transition period (1989–1993) between the previous and the current government was also considered. In the case of Ethiopia, government transition usually comes shortly after one another with land policy changes that cause quite considerable damage to the forest areas.

To map and quantify forest cover change two approaches were used: i) a point analysis of aerial photos and ii) a manual classification of the Landsat images. The aerial photographs were georeferenced to the imagery base map in Arc Map after identification of a minimum of ten control points. A second order polynomial with a nearest neighbor resampling approach was then used to transform the aerial image to the correct spatial location. A point count analysis, which is often used to extract statistical data from aerial photographs (Burton, Taylor, & Hicks, 2009) was applied. A point grid was also created over the

cropped aerial photos, with regularly placed points every 500 m. Each point was then manually classified as either forest or non-forest. The difference in points in each category was then used for forest cover change quantification. The selected Landsat imageries have a spatial resolution of 30–60 m (USGS, 2014). All images except one were taken between October and January (i.e. during the dry season), which also corresponds to the months with the least cloud cover. One image, however, is from March 1993 as it is the first Landsat image available for the area following the transition from the previous government to the current one.

In a number of satellite images, pixels with noise (i.e. 1972 - Bands 6 and 7, and 1975 - Bands 4 and 6) were manually reclassified to 'no data' and were therefore not included in any analysis (Tsai & Chen, 2008). A classification was carried out first by visualizing the Landsat images with a FCC, then manually delineating the forest areas into a vector file, which were then rasterized using the original cell size and alignment of the satellite image (either 30 m or 60 m), to later ultimately calculate the forest area. The accuracy of the calculated forest cover area for 2014 was assessed on the basis of about 40 ground control points (GCP) randomly selected using a GPS (GPSmap62 of Garmin).

2.3. Semi-structured interviews

An interview using semi-structured questions was carried out with the following three purposes (i) to compare the perception of stakeholders with the observed forest cover change analyzed from remote sensing data (ii) to capture the perception of stakeholders on forest cover change drivers during the last three regimes of Ethiopia, and (iii) to understand farmers' attitude on the forest strategies employed during the last three government regimes and their proposal for improved forest management to serve forest conservation and communities' wellbeing.

The semi-structured interviews addressed five sections: respondents' background information, forest resource use and access, forest cover changes and its drivers during three political regimes, forest management strategies during the last three political regimes that were rated using a Likert scale (Likert, 1932), and proposed forest management strategies.

Interviews were conducted with three groups of stakeholders: 60 farmers (among which 23 female), 20 forest guards, and 10 forest managers. The farmers were selected from four villages, fifteen from each village around the forest boundary to represent as much variation as possible. The guards were selected from five security camp sites scattered on the forest edge, two from each sites. The forest managers included three former and seven currently working staff members. Only interviewees of 44 and older were considered for the social survey in order to have a complete memory of the entire study period. The survey was carried out between July and November 2014. The interview questions were coded and prepared in a spreadsheet for further analysis. Stakeholders' perception on forest cover change during the three regimes was summarized in Table 3. Evaluation of forest management strategies during three regimes were compiled in Table 4 based on the criteria Farmers developed. Proposed forest management schemes were analyzed in relation with some social factors (age, gender, land holding size, household size, and education level), to identify which variables determine the proposed strategies (Table 5). The relationship between the proposed strategies and the independent variables were analyzed using Chi-square test for categorical values and Mann-Whitney *U* test for ordinal and continuous values.

3. Results and discussion

3.1. Forest cover changes under different regimes

Forest cover change maps resulting from the aerial photographs and satellite image analysis are presented in Fig. 2. The resulting overall accuracy was 97.9% with Kappa coefficient of 0.96 for 2014 forest cover area, suggesting that there is almost total agreement between the classification and the reality on the ground.

3.1.1. The late imperial era (1972–1975)

Quantification of forest cover during the late imperial (1972 1975) era indicated a decline in forest cover (Table 2; Figs. 2 and 3). In this period, the Mengesha Suba forested area declined by 1.6%, which resulted from a gradual degradation carried out by the local community living inside and around the forest. During this time the exploitation of forest resources was for construction and fuel wood purposes by the local private owners that were given controlled user rights. As the time was close to the transition to the socialist era, the unstable situation might have facilitated the forest clearance. Most of the forest cover loss in Ethiopia has been attributed to the agricultural modernization policy that encourages converting forest land to commercial farms (Bekele, 2003; Ayana, Arts, & Wiersum, 2013), but this is not the case in our study area. But similar trends of increased forest degradation during periods with weaker law enforcement were also reported from other East African forests (Sassen et al., 2013; Turyahabwe and Banana, 2008).

For only a small area north of the Suba forest that covers 8764 m of forest edge the analysis was made by using the 1937 aerial photographs (Fig. S1). For this area, the point count analysis indicated an increase in forest cover from 1937 to 1971. It is clear, however, that this method has a limited applicability for such small areas. Only 24 points covered the 1937–1971 time series. From among those the point counts showing forest increased from 13 (1937) to 15 (1965) and 16 (1971). Overall, in the area, the position of the forest edge did not change much over time, but instead it became sharper. The surrounding landscape changed dramatically, with a significant loss of vegetation between 1971 and 2016. This type of forest edge getting sharper and the agrarian landscape losing most of its woody vegetation, making the forests disconnected from the surrounding landscape is in line with observations in church forests in NW Ethiopia (Scull et al., 2016). Over the long term, between 1937 and 2016, the Suba northern edge was deforested by 42 ha and afforested by 24 ha, meaning a net deforestation of 18 ha over 8.8 km of forest edge. Estimation of only Suba forest with the same point analysis method reveals a forest cover decline by 3.5% during mid-imperial period (1965–1971) (Table S1; Fig. S2).

3.1.2. The socialist era (1975–1989)

The socialist era is the time when the lowest forest cover loss and considerable forest gain was observed compared to the other two political regimes (Table 2; Figs. 2 and 3). In the early and mid (1975–1986) as well as towards the end of (1986–1989) the socialist rule, the forest cover increased by 9% for each period (Table 2; Figs. 2 and 3). The forest cover increase between 1975 and 1986 mainly came from the 1975 land reform that claimed the community-owned Eucalyptus plantations (Duguma et al., 2009) for the state and transferred them to the Menagesha Suba state forest ownership (Bekele, 2003). In the late socialist era (1986–1989) the forest cover increased due to intensive afforestation that took place (Alemayehu, 2005) in the surrounding of the indigenous forest with exotic plantations, mainly *Cupressus lusitanica, Eucalyptus globulus, Pinus radiata, and Pinus patula*. The policy change that enforced afforestation was meant to protect the indigenous forest against encroachment and land degradation. This was done by establishing an exotic tree plantation forest as a buffer zone between the communities and the indigenous forest. Though this action yielded an increased forest cover and tackled successfully the communities from accessing the indigenous forest, the exotic forest offers less ES as compared to the indigenous forest (Tekalign et al., 2017). Moreover, it caused long-term conflicts between communities and forest managers, as there was strict restriction of forest access. The ES decline due to this decrease of the share of the indigenous forest was recognized as a characteristic of the forest quality loss of Menagesha

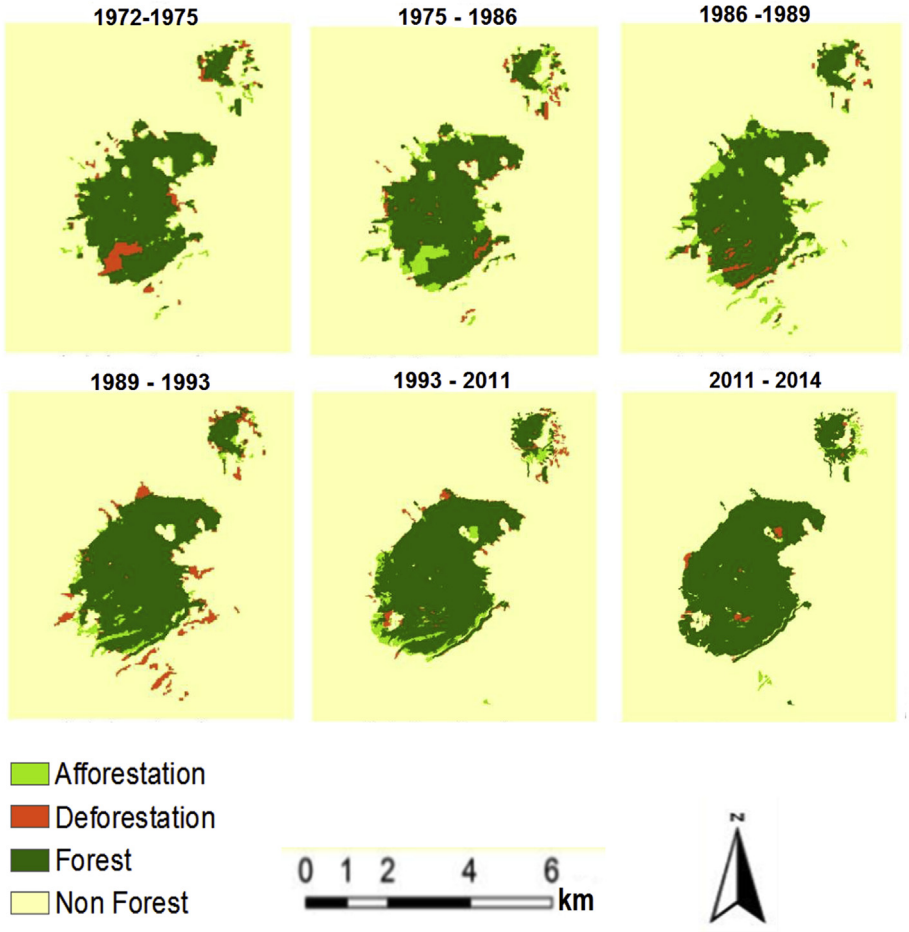

Fig. 2. Forest cover change maps of the study area from 1972 to 2014.

Suba forest by the local farmers during the stakeholders' group interview. Policies that have successful protection and regrowth of forests as their aim are supposed to contextualize the needs (in this case the need to increase forest ES provision) on the ground, in addition to forest biomass stock increase (Chazdon et al., 2016).

3.1.3. The transition period (1989–1993)

During this unstable period and the latest rule of the socialist era (1989–1993), a relatively higher forest cover decline of 3.9% was recorded (Table 2; Figs. 2 and 3). The forest was targeted by the local community members in areas where the farmers had forcefully been snatched ownership of their land because of the 1975 land proclamation during the socialist era. Widespread deforestation and degradation were observed in many parts of the country as a result of access restrictions to forest resources, expropriation of land, and erosion of local community's rights to their own resources (Eshetu & Högberg, 2000;

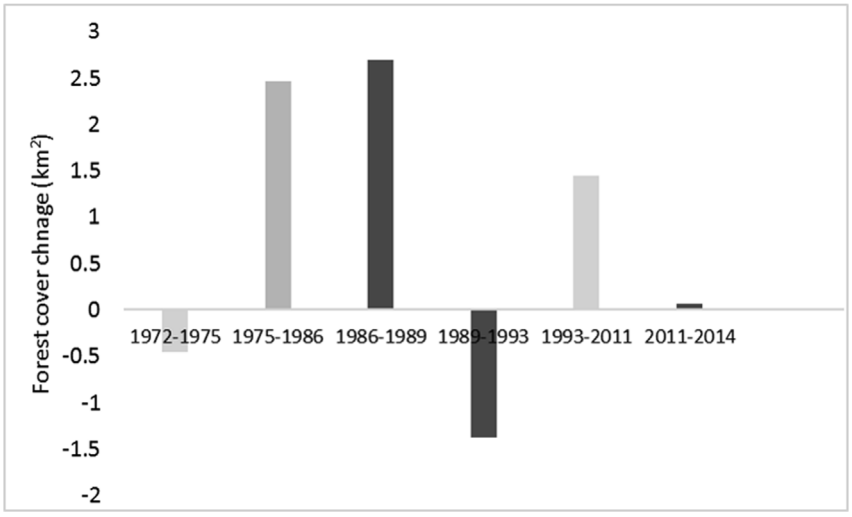

Fig. 3. Forest cover changes (net) in Menagesha Suba forest during different study periods.

Table 2
Relative forest cover change within the three government regimes from 1965 to 2014.

Year	Government regime	Area of forest cover	Forest cover change period	Forest cover (km^2)	Relative forest cover change	
					Forest cover change (km^2)	Forest cover change (%)
1937	Imperial	North-West (NW) of Suba forest edge	1937	3.25		
1965	Imperial	NW of Suba forest edge	1937–1965	3.75	0.5	15.4
1971	Imperial	NW of Suba forest edge	1965–1972	4	0.25	6.7
1965	Imperial	Suba forest		27.2		
1971	Imperial	Suba forest	1965–1971	26.24	−0.96	−3.53
1972	Late Imperial	Menagesha and Suba forest		28,03		
1975	Late Imperial	"	1972–1975	27.57	−0.46	−1.64
1986	Socialist	"	1975–1986	30.04	2.47	8.96
1989	Socialist	"	1986–1989	32.73	2.69	8.95
1993	Transition	"	1989–1993	31.47	−1.26	−3.85
2011	EPRDF	"	1993–2011	32.8	1.33	4.22
2014	EPRDF	"	2011–2014	32.88	0.08	0.24
			Total (1972–2014)		4.85	16.89

Table 3
Comparison of the perceived forest cover change with the observed forest cover change based on interview and remote sensing techniques respectively during three governmental regimes of Ethiopia. Numbers represent the percentage of respondents that perceived the changes.

Forest cover change	1972–1975 (Late imperial era)	1975–1989 (Socialist era)	1989–1993 (Transition period)	1993–2014 (EPRDF regime)
Perceived change				
Farmers (n = 60)				
Increase	_	100	_	58
Decrease	14	_	100	_
No change	86	_	_	42
Guards (n = 20)				
Increase	_	100	_	82
Decrease	32	_	100	18
No change	68	_	_	_
Forest managers (n = 10)				
Increase	_	100	_	100
Decrease	35	_	100	_
No change	65	_	_	_
Observed changes (%)	−3.53	16.27	−3.85	4.46

Dessie & Christiansson, 2008). The widespread deforestation and forest degradation during this transition period could be taken as a typical example of top-down command and control management approach.

3.1.4. The Ethiopian People's Revolutionary Democratic Front (EPRDF) regime (1993–2014)

During the EPRDF era, an overall increase of forest cover by 4.8% was observed. This is a small increase compared to the length of the period, 20 years. This might be linked to the agricultural intensification discourse where the forestry sector was given marginal attention (Ayana et al., 2013). On the other hand, MoFED (2010) reported that reforestation during the past decade has been making progress in the country and this has contributed to an estimated doubled forest cover, i.e. from 4.1 million ha to 8.8 million ha. However, this report has been controversial and seemed to lack credible data. Many forest cover change analyses in the past two decades show a decline of forest cover for an increased agricultural land (Ariti, Vliet, & Verburg, 2015; Biazin & Sterk, 2013; Hailu, Biniyam, Eduardo, Heiskanen, & Pellikka, 2015). A new forest policy was approved in 2007 for a strong and autonomous forestry sector (Mulugeta & Tadesse, 2010). However, its enforcement was challenged by the priority given to agricultural intensification, the insufficiency of funding and incompatibility with government policies of other sectors (Ayana et al., 2013; Nyssen et al., 2015).

3.2. Stakeholders perception of forest cover change

Stakeholders' perception on forest cover change under the three government periods clearly coincides with the observed forest cover change from the analysis of satellite imagery (Table 3) except in late imperial regime. During the late imperial regime (1972–1975) more than half of the stakeholders reported to have perceived no forest cover change, while the satellite images show a forest cover decline of 1.6% (Table 3). As the forest cover loss was small, stakeholders might not have noticed it or at least don't remember it. On the other hand, even though farmers correctly perceived an overall net forest cover increase during the study period, they brought to light forest degradation signs. These signs clearly show that the forest was undergoing a gradual loss of quality in terms of ES provision and forest composition. Farmers mentioned forest density and tree composition change over time of the Menagesha Suba forest as an indicator to compare forest quality change over the studied time period. The composition has changed from pure dense indigenous forest (*Juniperus procera, Afrocarpus falcatus, and Olea europaea*) during the imperial era, over a little less dense indigenous forest with exotic buffer (*Eucalyptus* spp, *Cupressus lusitanica*) in the socialist regime, to a sparse indigenous forests mixed with exotic forest in the current period. A farmer explained this change of forest quality deterioration by reflecting that “before, you couldn't see someone standing at a distance of 100 m in the forest, but now you can look through it over longer distance”.

3.3. Drivers of forest cover change

Stakeholders i.e. farmers, forest guards, and forest managers perceived similar forest cover change drivers over the three government regimes (Fig. 4). Government land policy was selected as a leading forest cover change driver by 61.5% of farmers, 60% of forest guards, and 60% of forest managers in the late imperial rule. Similarly, 55% of farmers, 50% of forest guards, and 44% of forest managers believed government land policy to be a leading forest cover change driver in the socialist military regime. Overall, 71.3% and 52.3% considered government land policy to be a major driver of forest change in the late imperial rule and in the socialist rule respectively.

The late imperial rule policy gave private land ownership to selected individuals for protection and exploitations and this was a cause of forest cover loss during that period. At national level, unlike Menagesha Suba forest, it is the agricultural intensification policy that was responsible for most of the forest cover decline (Bekele, 2003). During the socialist military rule (1975–1989), the 1975 government's land reform policy was indicated as the main driver behind the intensive afforestation program that increased the Menagesha Suba forest area by 17% (Table 2; Fig. 2).

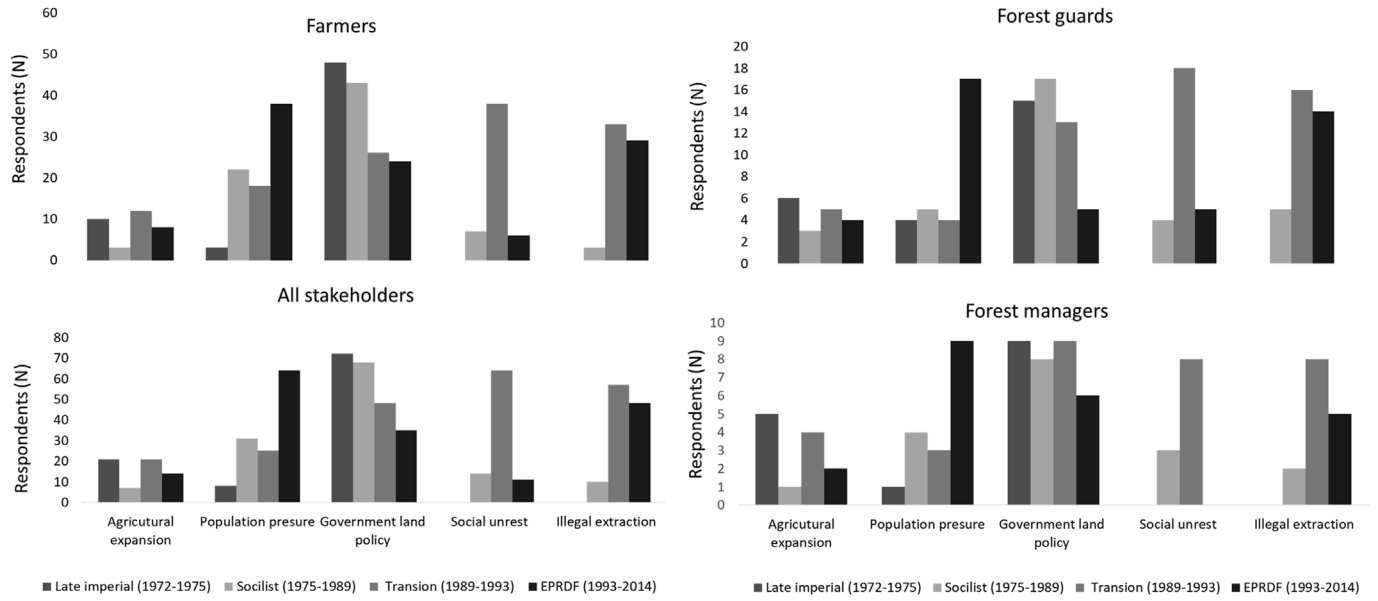

Fig. 4. Perceived forest cover change drivers by stakeholders (farmers, forest guards, and forest managers) during the three political regimes in Ethiopia. Values in the driver's table represent number of respondents.

Social unrest was believed to be the leading forest cover loss drivers in the transition period just before the subsequent EPRDF government by 30% farmers, 32% forest guards, and 25% forest managers. Similarly, illegal encroachment was believed to be a leading driver for loss of forest cover by 26% of farmers, 28.5% of forest guards, and 25% of forest managers.

Respondents explained that the top-down command and control management policy during the socialist era was the cause for the unrest and the illegal encroachment, which resulted in clearing a fraction (3.9%) of the forest area. The community perceived forest cover decline at this time as severe deforestation. One farmer described the deforestation in the transition time as "the community had perceived the forest as their enemy because of the total forest resource access prohibition during the socialist era. Hence, when the socialist regime was overthrown, the forest was attacked like an enemy."

The main driving factor in forest cover change during EPRDF rule (1993–2014) has been population pressure as informed by 37.3% of farmers, 32% of forest guards, and 41% of forest managers. Increased illegal encroachments was also considered as a driver for the stated change by 20% of farmers, 26% of forest guards, 23% of forest managers. During this period the forest cover has been somewhat in a stable condition (Fig. 2). The small forest cover increase during the current period comes from the annual plantation campaigns performed mainly with exotic tree species, which provides less ES than the indigenous trees (Tekalign et al., 2017). The forest cover remained stable with a small increase. However, stakeholders reported their concern that in addition to reduced ES provision, the forest was still undergoing a gradual degradation from illegal encroachment for charcoal and timber selling by the young and landless members of the community. Illegal encroachment is increasing because of the high market demand for forest products from the surrounding rapidly expanding urban towns (Holeta, Menagesha, and Sebeta) and the capital city, Addis Ababa. Duguma et al. (2009) reported that 42% of 381 households he sampled in the surroundings of Menagesha Suba forest, sold at least one type of forest products (charcoal, fuelwood, and pole) supposedly obtained from the forest. He reported that charcoal selling was a common off-farm activity carried out by a large number of households. He also identified that 23 m^3 of charcoal was supplied to the nearby two markets every day.

3.4. Evaluation of forest management strategies under three governmental regimes

The criteria farmers used to evaluate forest management approaches during the three regimes include dependency on the forest, illegal access to the forest, benefit sharing, community participation and conflicts. Farmers then rated these criteria between Very Low (1) to Very High (5) (Table 4) for each regime using Likert scale (Likert, 1932).

For the late Imperial and Socialist rules, the rating Very Low (1) and Low (2) were given for most of the forest management criteria. The communities' dependency on the forest, illegal forest access, and community participation were rated as Low by 82% of respondents for the late Imperial rule. The rating was poor because forest dependency and illegal access were not important during this time as demand for forest

Table 4
Perceived forest management strategies evaluation by stakeholders (only farmers for this specific case) during the three government regimes of Ethiopia. Icons represents rating of forest resource use and management by farmers (○ = Very low, ◔ = Low, ◑ = Medium, ◕ = High, ● = Very high).

Forest resource use and management	Imperial (1972–1975)	Socialist (1975–1989)	Transition period (1989–1993)	EPRDF (1993–2014)	
				Federal (1993–2007)	Regional (2007–2014)
Dependency on the forest	◔	◔	◕	◕	◑
Illegal forest access	◔	○	●	◔	◕
Benefit sharing	○	○	○	◑	○
Community participation	◔	○	○	◕	◔
Conflicts	○	◑	●	◔	◕
Best time the forest was managed	◔	○	○	◕	◔

products was low due to lower population pressure. The overall evaluation for the forest management strategy during the Imperial regime was rated Low by 80% of respondents as well. During the Socialist rule, the rating was Very Low for most of the forest management criteria but for different reasons than during the Imperial rule. There was a total restriction of the forest resources use, so there was very limited forest access. Hence, the evaluation rated Very Low for forest dependence, benefit-sharing, and community participation by 76% of respondents. Although the protection of the forest increased the forest cover, communities' use of the forest resources to meet their livelihoods was very limited. The sense of ownership among the communities also declined. This forced the community to incur additional costs for buying non-timber forest products such as fuelwood. Moreover, when regulatory control was weak after the Socialist regime was overthrown, the highest deforestation was recorded, 3.9% of forest cover loss. This was also observed in many cases of protected forests in the tropics that strict regulatory control and did not involve the local community. Forest cover decline exacerbated by creating de facto open-access regimes (Blackman, Pfaff, & Robalino, 2015; Wittemyer et al., 2008). In the EPRDF regime, the forest management period was evaluated for two administrative phases: Federal (1993–2007) and Regional (2007–2014). During the federal government, 88% of respondents rated the forest management approach as Good (4) for criteria: dependency on the forest, benefit-sharing, and community participation. For illegal access and conflicts, however, the rating was very low (1) by 79% of respondents. In the federal administration, farmers reported that they had actively participated in boundary delineation in 2004 and they volunteered in annual tree plantation campaigns. Moreover, community's key informants used to share historical knowledge of the forest with students and kids visiting the area. Farmers also benefited from the investment of 20% of the income share on public infrastructures from the Menagesha Suba forest office. Overall, the federal government administration was rated a higher level “Good” by 80% of the respondents. It was also referred to as the best time the forest was managed. Since the regional government took the forest management, the rating has dropped for dependency on the forest, benefit-sharing, and community participation. The rating, on the other hand, increased for illegal access and conflicts because the level of legal access is decreasing. Gavin and Anderson (2007) reported that local community would not abuse resource management until they are sure of getting the necessary products out of it for long period of time.

3.5. Proposed forest management activities and their determinates

Following lessons learned from the evaluation of the forest resource use and management approaches in the past three regimes (Table 4), farmers proposed management strategies as important measures for the sustainability of the forest. The proposed strategies included restricted forest access, community participation, grazing land availability, farmland tree planting, and ecotourism development. The importance of local community involvement and direct benefits to these communities for future sustainability of the forest is substantiated by researchers such as Amente, Huss, Tennigkeit, & Yemshaw, 2010; Denier et al., 2015, p. 158; and Amare et al., 2016.

Trees on the farmlands in particular and human modified landscape, in general, have had supported soil, biodiversity, and people's livelihood. This is important to the development of management and conservation plans (Athayde, Cancian, Verdade, & Morellato, 2015; Manning, Fischer, & Lindenmayer, 2006). Ecotourism has also been promoted due to its ability to provide income to local people and help conserve natural resources (Hunt, Durham, Driscoll, & Honey, 2015).

The relationship between the proposed strategies and some independent variables are presented in Table 5. Gender significantly determined access to forest resources. Women inclined more to have open access, mainly aiming for fuel wood use. This seemed to support a report that indicated gender differentiation in collection of forest products (Sunderland et al., 2014). The Mann-Whitney test revealed that farmers who have large household, smaller land, and who are younger in age proposed access to more grazing lands and ecotourism access. On the contrary, farmers who are older and with large land size preferred farmland tree planting.

Education level significantly determined several recommended strategies. Farmers that have completed primary and secondary school assumed community participation, farmland tree planting, and tourism development would ensure sustainable use of the forest as it would benefit the local communities. The positive influence of education and access to information on farmers resource conservation attitude is also reported in Obayelu, Adepoju, and Idewu (2014) and Adimassu, Kessler, and Hengsdijk (2012). As a closing question, farmers were asked their thoughts about the future fate of Menagesha Suba forest. They reported that they saw both risks and opportunities. Farmers believed that the cover and diversity of the forest would definitely decline as there was a high demand of forest resources from the nearby towns and the capital city Addis Ababa. However, farmers also hoped the pressure on the forest could decline in time, as many young people would be employed in the nearby expanding industries and as a result of the potential ecotourism development in the area. Urbanization is widely mentioned in literature both as a threat (Seto, Güneralp, & Hutyra, 2012) and opportunity (Rudel, 2013) in forest cover change in the tropics.

4. Conclusions

This study examined forest cover changes over a period of five decades and its drivers with the aid of remote sensing-based forest cover mapping and perception of stakeholders. The fluctuating trend of the observed forest cover change stemmed from remote sensing analysis almost consistently matched with the perceived forest cover change by stakeholders. Stakeholders fully agreed on the results of the observed forest cover change, however, they wanted to inform that the forest has also been undergoing gradual loss of quality from a decline of ES provision. Such a decline could have not been identified with the observed forest cover change.

In Menagesha Suba forest, forest policies implemented by the three government regimes have played a considerable role as drivers for both forest cover loss and gain. That was in addition to other forest cover change drivers (Agricultural expansion, population pressure, social unrest etc.). This is quite different from the forest cover change drivers usually reported in Ethiopia and in the tropics. Farmers considered the growing population and expanding towns as a future threat to the forest. They also saw opportunities from the emerging industrial zones and potential ecotourism developments, which might reduce the pressure of forest resources exploitation. From the stakeholders' interview, farmers seemed to have a good recollection of the forest management strategies implemented in the last three regimes. According to the farmers' evaluation, the best time during which the forest was managed was when there were restricted forest access, benefit-sharing, and community participation.

The future management of Menagesha Suba forest supposedly needs to integrate local stakeholders' preferences, while giving due consideration to social backgrounds such as age and literacy level. The implementation of community supported management (in our case community participation, ecotourism, and farmland tree planting) have shown positive outcomes for forest conservation elsewhere. Overall, the findings of this study suggest that past management in Menagesha Suba forest failed to keep the productivity of the forest in its ES provision and integration to the local stakeholders. Therefore, it requires meticulous planning and consideration of strategies that maintain and improve forest quantity and quality in terms of biodiversity and ES provision. At the same time stakeholders' participation in the forest management could be facilitated in such a way that they will have alternative means of income.

Table 5
Proposed forest management strategies by the local farmers and its socioeconomic determinants.

Independent variables	Proposed strategies					
	Restricted access	Community participation	Grazing land availability	Farm tree planting	Eco-tourism	Tests
Respondents (%)	57.5	67.5	75	85	77.5	
Age	0.891	0.978	0.0000***	0.027**	0.0000***	Mann-Whitney
Gender	0.014**	0.916	0.519	0.144	0.204	Chi-square
Educational level	0.601	0.000***	0.693	0.082*	0.000***	Chi-square
Land size	0.597	0.890	0.0001***	0.016**	0.006**	Mann-Whitney
Household size	0.394	0.340	0.0145**	0.711	0.073*	Mann-Whitney

*P < 0.1, **p < 0.05, ***p < 0.001.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.apgeog.2018.07.014.

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