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Impacts of Resettlement Programs on Deforestation of Moist Evergreen Afromontane Forests in Southwest Ethiopia

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Severe land degradation and the consequent series of drought and famine episodes have caused major waves of human migration in Ethiopia over the past 5 decades. The main objective of this study was to assess the impacts of consecutive resettlement programs (spontaneous and planned) on the forests in southwest Ethiopia. The spatial distribution and extent of forest cover were mapped for the periods 1957, 1975, and 2007 based on visual interpretation of aerial photographs and satellite images. The rate of deforestation was analyzed using overlay and buffer analysis techniques available in ArcGIS software. Focus group discussions and household surveys were conducted to collect information on landscape (forest) change and the causes and consequences of deforestation. Results from the forest cover change analysis revealed that the study area lost large tracts (80%) of its forest cover between 1957 and 2007. Demographic, socioeconomic, and cultural changes introduced by migrants were the leading drivers of deforestation in the study area. In addition, the rate of deforestation in the region has been exacerbated by a low level of education and awareness of the local people about the benefits of forests, lack of regulations to protect the forests, habitat destruction to deter crop-damaging wild pests, forest clearing for fuelwood and charcoal making, and wood extraction for construction and household furniture purposes.

Keywords: *Deforestation; migration; migrant; indigenous; resettlement; southwest Ethiopia.*

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Introduction and problem statement

Human migration is a voluntarily or involuntarily movement of individuals or groups of people from one geographic setting to another (National Geographic Society 2005; Black et al 2011). Migration can happen on a temporary or permanent basis. It is driven by a range of proximate and underlying factors, including economic drivers (eg better job opportunities and higher incomes), sociodemographic factors (eg religion- and ethnicity-related conflicts), environmental problems (eg floods, landslides, earthquakes, and droughts), and political factors (eg civil war, persecution, and discrimination) (Bates 2002; IOM 2004; Adewale 2005; Heinonen 2006; Black et al 2011; Mulugeta and Woldesemait 2011; FMO 2012; Van Hear et al 2012).

Migration can result in multiple and complex impacts on the socioeconomic and environmental characteristics of the receiving area. Several studies have assessed the socioeconomic, planning and policy, and safety aspects of migration (eg Rahmato 1988; Alemneh 1990; Kloos 1990; Pankhurst 1990, 1992; Wolde-Silassie 2002; Erlichman 2003; Hammond 2008). Other studies have offered evidence of the severe environmental degradation caused by migrants in different parts of the world, such as accelerated deforestation (Myer and Turner 1992; Turner et al 1993; Ojima et al 1994; Lambin et al 1999; Geist and Lambin 2001), soil degradation, and depletion or pollution of surface and subsurface water resources (Young 1985; Allan 1987; Wood 1993; Reid et al 2000; Woube 2005; Limenih et al 2012; Getahun et al 2013; Tadesse et al 2014).

Ethiopia can be considered one of the global hotspots of internal migration: during the last decades, millions of people have been migrating within the country, mostly from the famine-affected and semiarid northern part of the country to the more tropical southwestern part (Ezra 2001; Pankhurst 2009). Parts of these migrations were voluntary, while others were involuntary in the framework of state-sponsored resettlement programs (Mulugeta 2009; Mulugeta and Woldesemait 2011).

Several studies that aimed at assessing the environmental consequences of these intra-Ethiopian migrations suggest causal links between migration and deforestation (eg Rahmato 1988; Getachew 1989; Rahmato 2003). These authors describe the impact of these migrations as socially disruptive, affecting the livelihood system of the indigenous people in southwestern Ethiopia, which was highly dependent on the forest ecosystem from which they extracted various non-timber forest products (eg honey, fruits, spices, coffee, and firewood). The new migrants not only cleared forest for new farming land but also introduced different oxen-based farming systems from the north, a farming system that depletes the natural resources more rapidly than the traditional local practices of hoe-based shifting cultivation (Feleke 2004; Ahmed 2005; Woube 2005). All these authors conclude that the migration-driven disruptions led to severe environmental degradation in the form of deforestation, soil depletion, and extinction of wild animals.

All previously mentioned studies are based on qualitative observations of migration and environmental degradation. Until now, there was no quantitative analysis of the true impact of migration-stimulated degradation. By providing quantitative information on migration-driven environmental degradation, however, new insights could be generated on how to steer migration fluxes in a more sustainable direction. Therefore, this study hypothesized that both spontaneous and state-sponsored resettlement programs have resulted in a rapid depletion of forests in southwestern Ethiopia that is measurable and quantifiable by means of diachronic land cover mapping. It also hypothesized that it is possible to disentangle the impact of the increased population pressure on land resources, on the one hand, and the impact of the introduction of new livelihood systems, on the other hand.

The study therefore investigated the impacts of migration on the forests of southwestern Ethiopia through (1) the collection and systematic analysis of information on migration, (2) the detection and mapping of the evolution of forest cover change in space and time, and (3) an assessment of the local livelihood system and its impact on forest disturbance. The study focused on southwestern Ethiopia, because this area been a major destination for migrants from various parts of Ethiopia over the last several decades.

Study area and migration patterns

Historically, human migrations in Ethiopia have been caused by conflicts, environmental degradation, and more recently, development-related factors (Yntiso 2003; Mulugeta and Woldesemait 2011). For example, overcultivation (a process in which cropland is used intensively and over a long period with a very short or no fallow period) in northern Ethiopia has resulted in severe soil degradation. As a consequence, famines have occurred more frequently, and there have been several episodes of human displacement and outmigration (Figure 1) (Wood 1977; Butzer 1981; Pankhurst 1990; Brancaccio et al 1997; Bard et al 2000; Darbyshire et al 2003; Nyssen et al 2004; Belay et al 2014).

Environmentally induced migration has remained the leading cause of human migration in Ethiopia because of the large number of people involved and its frequency of occurrence (Mulugeta and Woldesemait 2011). This type of migration is usually attributed to the occurrence of recurrent droughts and famines, which are exacerbated by erratic rainfall distribution and poverty (Aredo 1987; Rahmato 1989; Pankhurst 1990, 1992; Ezra 2001; Rahmato 2003; Gray and Muller 2007; Gray and Mueller 2011).

Environmentally induced spontaneous migration in Ethiopia was recognized as early as the 1950s (Smeds 1956). Spontaneous migration is a type of voluntary migration based on the free will of the migrants (UNDESA 2016). More than 1 million people were estimated to have migrated in this way in the 1950–1970 period (Wood 1982, 1985; Woldemariam 1986; Casacchia et al 2001; Mberu 2006; Fransen and Kuschminder 2009). Meanwhile, state-sponsored (planned) resettlement programs have been implemented by successive Ethiopian governments since the late 1950s (Cernea 2000; Yntiso 2004; Fosse 2006; Yntiso 2009). During the imperial era between 1958 and 1974, 20,000 households (about 104,000 people) were moved from drought-affected and overpopulated regions in the northern and north-central highlands and resettled in the south (Feleke 2004).

In the 1970s and early 1980s, drought and famine events reached crisis levels in north and north-central Ethiopia. Resettlement programs were seen as an immediate solution to the problem (Rahmato 1988; Kloos and Adugna 1989; Kloos 1990; McCann 1995; Belay 2004; Limenih et al 2012), and 343,000 households (about 1.7 million people) were resettled in southwestern and western Ethiopia in 1984–1985 (Getachew 1989; Ezra 1997, 2001; Rahmato 2003; Yntiso 2004, 2009; Mberu 2006; Pankhurst 2009). Southwestern Ethiopia accommodated about 600,000 (35%) of the migrants who reached their final destinations (Tadesse et al 2014).

The recent drought and famine episodes that occurred in the early 2000s have again resulted in severe food security problems. Once more, the government has looked to intraregional resettlement programs to help resolve the problem (Fransen and Kuschminder 2009). Since 2003, about 1.5 million people have been resettled in areas with high agricultural potential in Oromia, Amhara, Tigray, and the Southern Nations regional states (NCFSE 2003; MoFED 2006; Hammond 2008).

To study the environmental consequences of the series of resettlement programs implemented in southwestern Ethiopia, 8 rural villages (Abokoy, Bilo, Chalte-Bulte, Ilala, Keta-Kedida, Korjo, Ofole-Dawe, and Sito) and a single rural town (Sheki) were selected from the Dedo District,

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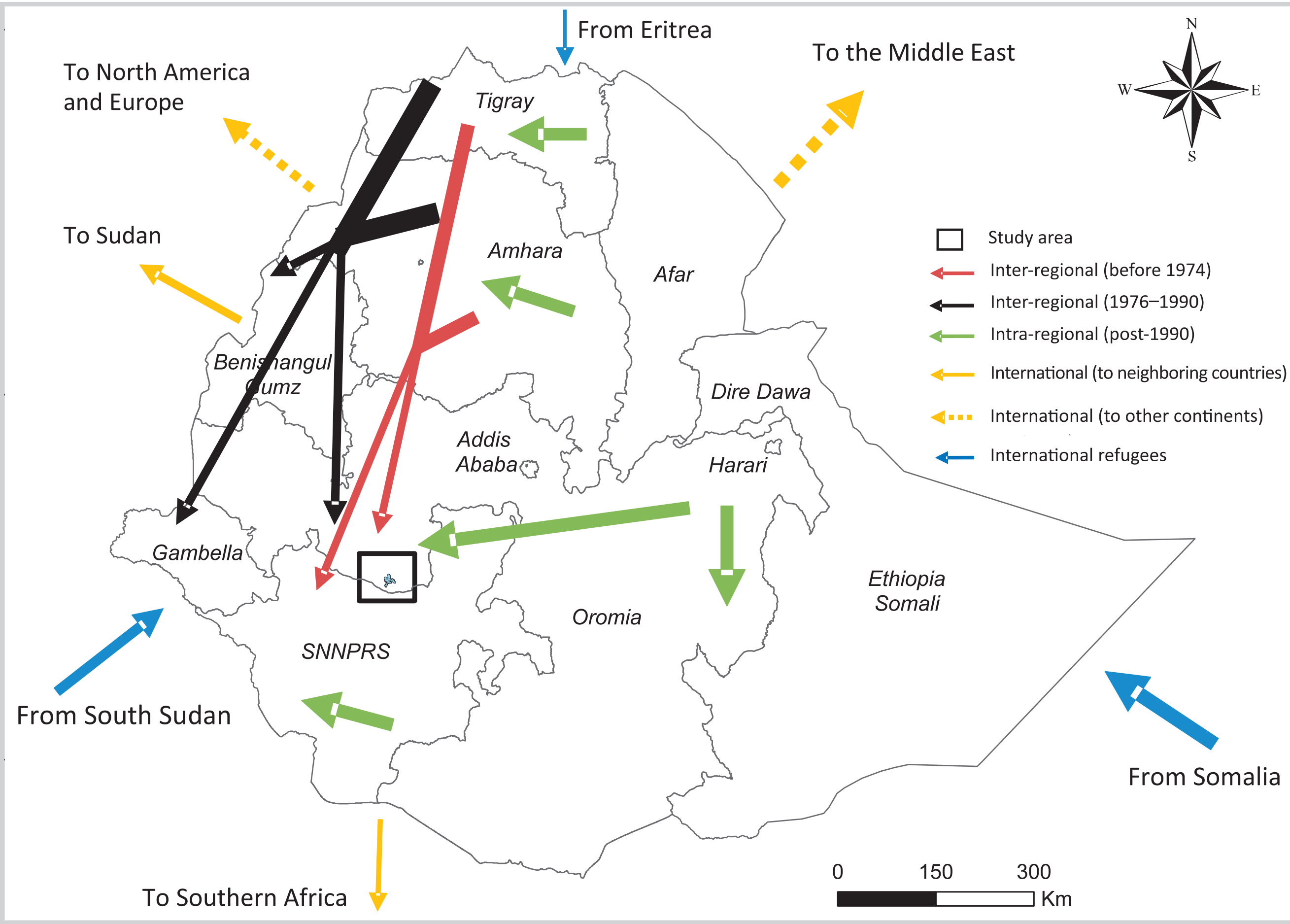
FIGURE 1 Historical migration routes in Ethiopia based on information from various research works. The thickness of the arrows depicts the magnitude of migration flow. (Map by Kefelegn Getahun)



which is located about 360 km southwest of Addis Ababa (Figure 2). The study area extends between 7°25′13″N–7°36′4″N and 36°48′36″E–36°57′4″E and covers a total area of about 137 km^2.

The topography of the study area is characterized by an alternation of flat plateaus and rolling hills; the overall elevation ranges between 1700 and 3000 masl. The study area receives 900–2200 mm of rainfall a year, while the average air temperature varies between 15–25°C. The local economy and livelihood strategy is characterized by mixed farming systems, which include growing of cereal crops (eg wheat, barley, fava bean, common bean, teff, maize, and sorghum), cash crops (eg coffee and pepper), and livestock breeding (Oromiya Livelihood Zones Reports 2007).

Material and methods

Forest cover mapping

The forest cover in the study area was mapped through visual interpretation of aerial photographs at a scale of 1:50,000 for 1957 (acquisition date: 12 December 1957) and 1975 (acquisition date: 20 November 1975). An additional forest cover map was produced for 2007 through visual interpretation of the SPOT satellite image (resolution: 5 × 5 m) captured 3 December 2007. Next, the aerial photographs and the satellite image were coregistered geometrically on the same datum and geographic coordinate system (WGS1984, Universal Transverse Mercator zone 37) via ground control points collected in the field using handheld global positioning system (GPS) units. Spatial data on national and village boundaries, roads, and river networks were obtained from the digital database of Ethio-GIS (2004) and the Central Statistical Agency of Ethiopia (CSA 2007).

Forestland units for 1957, 1975, and 2007 were mapped following Food and Agricultural Organization (FAO 2006) guidelines, whereby a land unit was considered forested if it covers an area of ≥0.5 ha and has a canopy cover of more than 10%. Accordingly, forestland units in the study area were identified visually on the basis of their texture and color (typically dark gray on panchromatic imagery) (Getahun et al 2013). Boundaries of the forest polygons were digitized using ArcGIS

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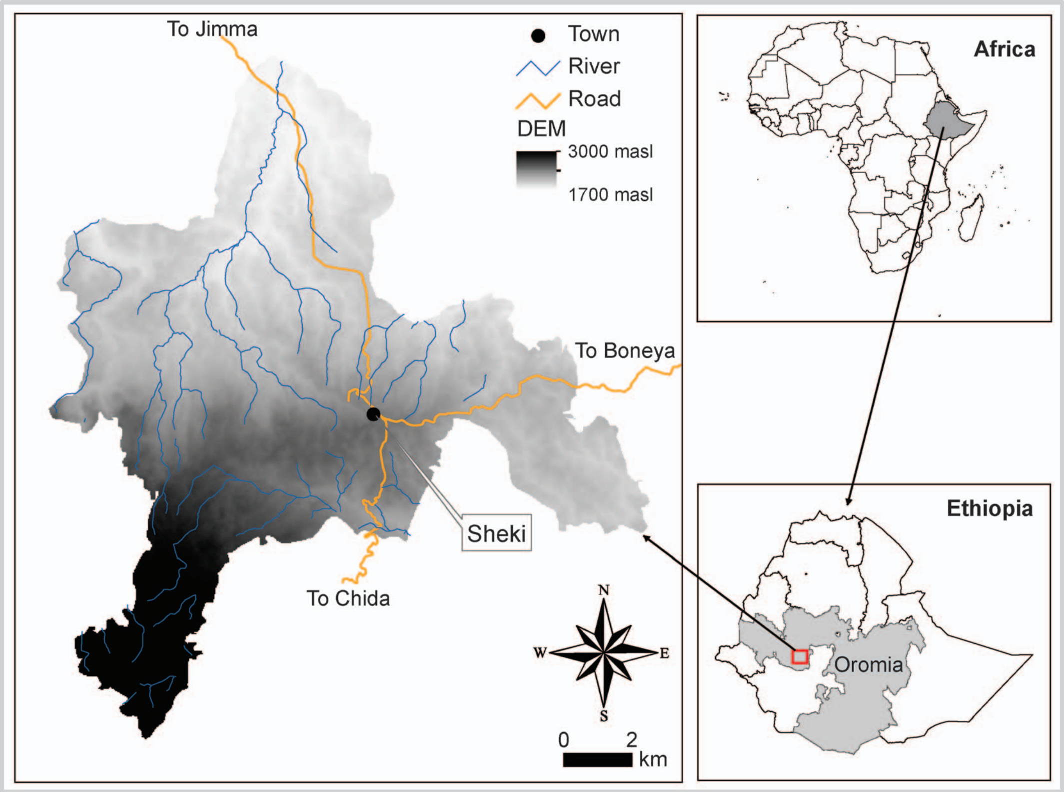
FIGURE 2 Map of the study area in southwestern Ethiopia (digital elevation model extracted from the Advanced Spaceborne Thermal Emission and Reflection Radiometer). (Map by Kefelegn Getahun)



software, and the forest cover maps for the respective periods were overlaid to produce deforestation and afforestation maps. Deforestation rates were then determined following Equation 1 after Puyravaud (2003):

$$P = \frac{100}{t_2 - t_1} In \frac{A_2}{A_1}, \qquad (1)$$

where P is the percentage of the annual rate of forest loss and A_1 and A_2 refer to the area of forest cover at times t_1 and t_2, respectively.

Focus group discussions and household survey

To understand the relationship between observed forest cover change and local livelihood systems in the study area, focus group discussions (FGDs) were conducted in 3 villages in mid-February 2011. The sample villages were selected to best represent the observed forest cover change patterns in the area. Each of the focus groups was composed of 8 to 10 individuals with diverse sociodemographic (eg gender), age (30–80 years old), and sociocultural (eg indigenous vs migrant) backgrounds. Members of the focus groups were consulted for the reconstruction of village timelines (1957 until 2011), which consisted of the following major themes: demographic changes, socioeconomic characteristics and livelihood systems, and deforestation processes. The convergence and divergence of views and ideas held by FGD participants were analyzed against the observed forest cover changes in the study area (Limenih et al 2012; Tadesse et al 2014). The information generated through FGDs was later used for triangulation and validation of household interviews.

Following the exploratory FGDs, an extensive house-to-house survey that involved 845 households was conducted using a semistructured interview method. A multistage sampling method was used to select households to participate in the final interview. In the first stage, 8 villages *(kebeles)* were selected on the basis of the extent of their forest cover in the past (1957–2007). Next, households were randomly selected based on the population registry, which was used as a sampling frame. The percentage of migrant households included in the sample was proportional to the fraction of the total number of households in the study area (about 10%). The location of the interviewed households was tagged with a handheld GPS with a precision level of about 5 m. The data collected from the households were analyzed using SPSS and Stata statistical software packages. Summary statistics were computed to summarize key variables, and the results were presented using frequency tables, percentages, and graphs.

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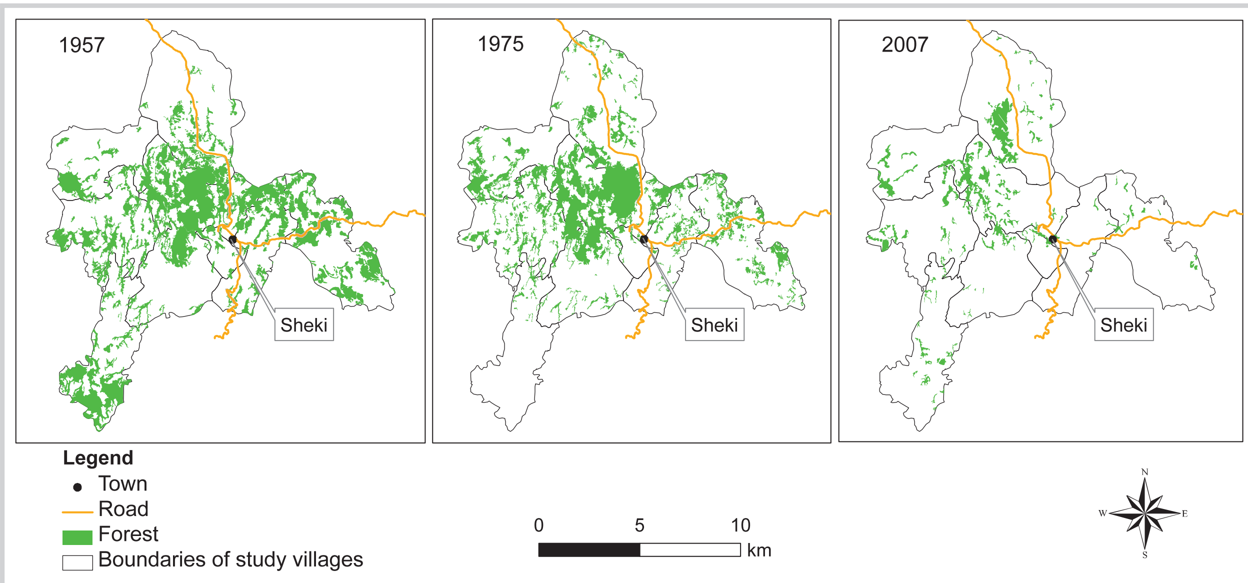
FIGURE 3 Extent of forest cover in the study area in 1957, 1975, and 2007.



Buffer analysis

We decided to map forest cover change at the household level to extract information regarding the extent of forest area cleared by different household categories. However, mapping individual parcels belonging to each household was not a straightforward process. The poor spatial and spectral resolutions of the panchromatic aerial photographs in particular hampered the clear identification and delineation of parcel boundaries. We therefore opted for buffer analysis that included the following steps:

1. A buffer zone with a 500-m radius was created around each of the sampled households. This radius was chosen based on the assumption that an individual or group of people in the study area travels an average distance of 500 m from the boundary of their *kebele* to clear forests for various purposes. This assumption was based on information obtained from FGD participants, who reported that migrants are typically resettled close to forest edges.
2. Land use change within the delineated buffer zones was mapped and quantified. Information about forest cover within the buffer zones was later used to compute annual rates of deforestation and to identify the degree to which individual households exerted pressure on forest resources.

Results

Forest cover dynamics

Results of forest mapping showed that the forest cover in the study area declined from 3973 ha in 1957, to 2740 ha in 1975, to 875 ha in 2007. This is a decrease of about 80% in 5 decades. This corresponds to average annual deforestation rates of 2.06%, 3.56%, and 3.02% for the periods 1957–1975, 1975–2007, and 1957–2007, respectively. The rate of deforestation during the 1975–2007 period was much higher than the rate recorded for 1957–1975. The years between 1975 and 2007 represent the period during which most migrants from northern and north-central Ethiopia were resettled in parts of the study area as a result of the deadly famines of the 1980s.

The spatial distribution of forest cover in the study area for 1957, 1975, and 2007 is shown in Figure 3. In 1957, the central and southern tip of the study area was largely forested. Forest cover in the southern tip of the study area was completely cleared in 1975, and by 2007, the forest was limited to tiny fragments, with only a few patches left in the northern corridor.

Deforestation hotspots were concentrated in the southwestern part of the study area during 1957–1975 (Figure 4). Deforestation during 1975–2007 was mostly limited to the central part of the study area, where large forest blocks were removed compared to the relatively small patches of deforestation during the previous period.

Household characteristics

In this study, 781 of 845 selected households participated in the interviews (92% response rate). Of the total interviewed households, about 10% were migrant households, which corresponds to the assessed total percentage of migrant households in the study. Of the migrant household heads, about 8% hold a college diploma or above (Table 1).

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FIGURE 4 Evolution of forest cover change in the study area during the periods 1957–1975 and 1975–2007.

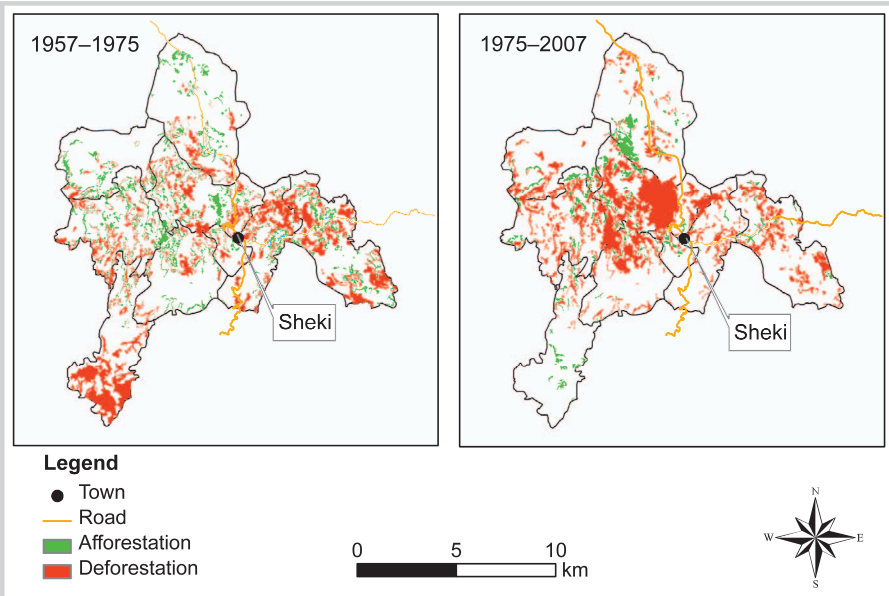

TABLE 1 Household characteristics of the study population.

Household characteristics	Indigenous households		Immigrant households	
	Number	%	Number	%
Marital status				
Married	676	94.28	58	90.63
Single	7	0.98	1	1.56
Divorced	2	0.28	—	—
Widowed	32	4.46	5	7.81
Main occupation				
Farming	582	82.44	51	80.95
Small-scale trading	86	12.18	4	6.35
Civil servant	21	2.97	6	9.52
Daily laborer	17	2.41	2	3.17
Educational background of household head				
Illiterate	458	64.06	49	76.56
Grade 1–4	117	16.36	5	7.81
Grade 5–8	98	13.71	2	3.13
Grade 9–12	23	3.22	3	4.69
College diploma and above	19	2.66	5	7.81

Local perception and feedback on causes of deforestation and foreseen conservation strategies

Most (92.4%) interviewed households reported the presence in their childhood (up to 30 or 40 years ago) of vast and dense forest resources in their direct neighborhood. Only 5.8% of the households mentioned that their direct neighborhood was already deforested decades ago.

The respondents attributed the major causes of deforestation in the study area to the following 6 causes, in decreasing order of importance: farmland expansion. population growth because of the high rate of natural increase and migration. low levels of education and awareness. forest habitat destruction to deter crop-damaging wild pests (monkeys, warthogs, wild pigs, etc). high demand for construction materials and wooden furniture in nearby towns (eg Jimma and Sheki). fuelwood and charcoal making. and lumber extraction (Figure 5).

About 40% of the indigenous and 28% of the migrant households reported farmland expansion by smallholder farmers as the leading cause of deforestation. According to 33% of the indigenous and 38% of the migrant households, deforestation was caused mainly by increased population pressure because of high natural birthrates and the influx of a large number of migrants. In addition, 14% of the respondents reported that low levels of education and awareness, along with lack of regulation to protect the forests, had aggravated deforestation in their local area.

List of proposed forest conservation and management strategies by the local inhabitants is shown in Table 2.

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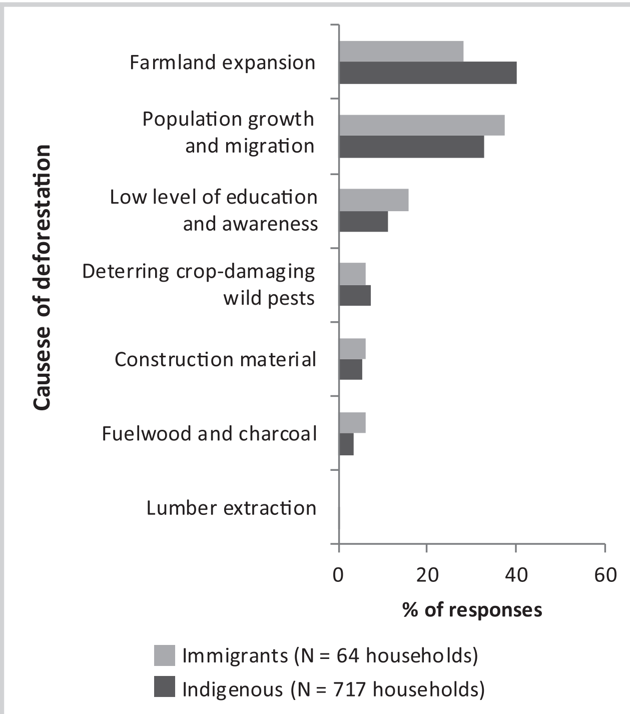
FIGURE 5 Causes of deforestation in the study area based on household interviews.



Buffer analysis

The average extent of forest cover that existed in 1957, 1975, and 2007 within a 500-m radius of each household category is given in Table 3. The data show that the forest cover declined on average by 28% between 1957 and 1975 and by 75% between 1975 and 2007. A per-category (migrant versus indigenous households) analysis shows clear differences between both groups. The forest decline observed for pre-1975 migrant households was 37% and 84% for the same periods. For those migrants who resettled between 1976 and 1990, the forest cover had declined by 80%, while 63% forest loss was observed for post-1990 migrants.

The annual rates of deforestation by different household groups within the 500-m buffer zones are shown in Table 4. For indigenous and pre-1974 migrant households, the annual rate of deforestation was higher from 1975 to 2007 than over the whole period (1957–2007). The rate of deforestation by all migrant groups (except for post-1990 migrants) was higher than that of indigenous households during 1957–1975 and 1975–2007. Overall, pre-1974 migrants were found to have put more pressure on the forest over the whole period than did indigenous inhabitants.

Discussion

Results from this study show that the study area has experienced widespread and rapid forest loss over the past 50 years. This is in line with the findings of Urgessa (2003), who also detected acute deforestation in the Dedo District, which is part of the study area.

First, the deforestation observed in the study area can be linked to the expansion of farmland by smallholder farmers to satisfy the increased demand for food and other consumables. This demand is the result of high population pressure caused by high natural birthrates and the influx of a large number of migrants from other parts of Ethiopia. For example, of the 600,000 migrants

TABLE 2 Forest conservation and management strategies proposed by local people.

Forest conservation and management strategies	Justifications and activities required	Responsible bodies
Organizing afforestation campaigns through mass mobilization	Because existing open fields are already occupied by croplands, marginal lands at farm fringes should be planted with trees	Local people, district administration, Bureau of Natural Resource Management and Environmental Protection
Preserving the remaining forests and practicing reforestation	This involves leaving the forest to regenerate naturally by establishing area closures	District administration, local people
Creating more awareness within the local community about the benefits of forests	Deforestation in the past was due to a lack of awareness about the environmental and socioeconomic benefits of forests	District administration, Bureau of Natural Resource Management and Environmental Protection
Increasing agricultural productivity	The adoption of adapted farming techniques will reduce the pressure on forest resources	Bureau of Agriculture and Rural Development, local people
Making energy-efficient cooking stoves available to local inhabitants at affordable prices	This would reduce demand for fuelwood and contribute to forest restoration	Federal government, regional government, nongovernmental organizations, district administration

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TABLE 3 Forest cover within a 500-m radius of the different household categories.

Household type	Forest cover (ha)[a]				
	1957	1975	2007	Mean	SD
All households (indigenous and immigrant)	3383	2449	609	2147	1411.4
Indigenous households	3314	2382	586	2094	1386.7
Immigrants before 1974	549	344	55	316	348.2
Immigrants between 1976 and 1990	NA	534	105	213	283
Post-1990 immigrants	NA	63	23	28.67	32

[a] SD, standard deviation; NA, not applicable.

originating from northern and north-central Ethiopia in 1984, 13% were resettled in parts of the Jimma Zone (where the study area is located), Shewa, and Gondar (Wubneh 1991; Pankhurst 1992; Ezra 2001; Tadesse et al 2014). Likewise, of the 78,000 migrants who moved during the second phase of the study period (1975–2007), 62% were resettled in the study area. A high birthrate and resettlement programs resulted in a 119% increase in population in the study area between 1984 and 2011.

The population boom experienced in the study area occurred so rapidly that the indigenous inhabitants were unable to adjust their livelihood systems to deal with the increased demand for food, fuelwood, and other natural resources. This rapid increase aggravated the conflict between indigenous and migrant households over resource use and led to rampant resource extraction and deforestation. Yonas et al (2013) also reported that migration resulted in the intensification of conflict over land resources among pastoral communities in the Meinit-Shasha District in southwestern Ethiopia. Moreover, according to Wood (1993), resettlement programs in other provinces in southwestern Ethiopia resulted in abrupt population increases (eg Ilu-Aba Bora, 7%, and Kaffa, 1%) and an associated drastic loss of forest surrounding the resettlement sites.

Resettlement programs have also introduced certain changes with regard to land use practices and the socioeconomic and sociocultural attributes of the local people. There has been a shift from the traditional system of hoe-based shifting cultivation, hunting, and gathering of non-timber forest products to a system centered on shifting cultivation with intensive oxen-plough cereal farming practices (Wood 1993; Rahmato 2003; Tadesse et al 2014). Traditional hoe-based shifting cultivation, practiced primarily by indigenous households, has a relatively low impact on the forest ecosystem, because it only requires the thinning of the dense undergrowth shrubs, rather than the complete clearance of the forest. In contrast, the intensive oxen-plough cereal farming system, which was introduced by the migrants and later adopted by indigenous households, involves the partial or complete removal of primary forests to cultivate cereal crops such as teff. This intensive oxen-plough cereal farming has resulted in a gradual decline in the fertility of soils on older farm plots (Table 5). Before the 1950s, this form of agriculture was not widely practiced in southwestern Ethiopia, because the low population pressure did not require an intensive cultivation of the land to feed the population. Upon the arrival of the immigrants from the north, the indigenous and low-productivity farming system no longer sufficed to feed the population. Moreover, the traditional livelihood required specific knowledge of forest products that the newcomers did not have; instead, they imported their farming

TABLE 4 Annual rate of deforestation within a 500-m radius of households.

Household type	Annual rate of deforestation (%)[a]				
	1957–1975	1975–2007	1957–2007	Mean	SD
All households (indigenous and immigrant)	1.53	2.34	1.63	1.83	0.44
Indigenous households	1.56	2.35	1.64	1.85	0.43
Immigrants before 1974	2.07	2.62	1.79	2.16	0.42
Immigrants between 1976 and 1990	NA	2.50	NA	NA	NA
Post-1990 immigrants	NA	1.98	NA	NA	NA

[a] SD, standard deviation; NA, not applicable.

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TABLE 5 Livelihood systems practiced by indigenous and immigrant populations and the associated level of pressure on forest cover.

Livelihood system	Household type		Level of pressure on forest cover
	Indigenous	Settlers[a]	
Hunting	X	NA	Minimal
Gathering of non-timber forest products	X	NA	Minimal: coexistence with standing forests
Indigenous shifting cultivation (hoe-based farming)	X	NA	Moderate
Immigrant shifting cultivation (intensive oxen-plough cereal farming)	X	X	High: reduction of fallow periods; does not match the agroecologic and climatic context; fierce competition and rivalry between local people and migrants over forest use; introduction of exotic crops and trees species (eg eucalyptus); decline in grazing land
Sedentary farming	X	X	Most productive form of farming if adapted to conditions; results in the lowest pressure on the land if expressed in per capita impact

[a] NA, Not applicable.

techniques from the north. In addition, because the newcomers were installed in separate villages and spoke a different language, communication between the indigenous and the migrant populations was limited. Only gradually did the indigenous population—which could no longer maintain its traditional livelihood system because of a shrinking territory—start copying the practices of the newcomers. The introduction of the intensive oxen-plough cereal farming system thus put enormous pressure on the region's forest resources and resulted in deforestation and forest degradation (Wood 1993; Bekele 2003; Stellmacher 2007).

In addition to introducing the intensive cereal farming system, pre-1974 migrants largely settled in the vicinity of pristine forest areas, rather than in areas that had already been cleared. As a result, pre-1974 migrants were responsible for clearing more forest than post-1974 migrants, who settled after most forests had already been cleared. Forest and woodland losses caused by both hoe-based and intensive oxen-plough shifting cultivation by migrants have been reported for other parts of Ethiopia and for Latin America (eg southwestern Ethiopia, Yonas et al 2013; central Ethiopia, Mulugeta 2009; northeastern Ethiopia, Tsegaye et al 2010; northwestern Ethiopia, Walle et al 2011 and Limenih et al 2012; and the Amazon region in Brazil, Peres and Schneider 2012).

This study finds a significant negative relation between education and deforestation: the higher the education level, the lower the deforestation rate. The interpretation of this correlation is debatable. According to scholars such as Godoy et al (1998), Cleaver and Schreiber (1991), and Hedge et al (1996), primary education could reduce the dependency of rural people on forest resources for their livelihood by increasing their chances of earning extra income from on-farm and off-farm activities. Getahun et al (2013) were able to show that off-farm jobs generated by secondary city development were able to reduce deforestation in the villages surrounding these cities. However, other scholars (Mena et al 2006; Babigumira et al 2014) reported that education may aggravate deforestation by facilitating access to agricultural loans and machinery for forest clearing. In the presented case study, the gradual increase in literacy over time coincides with a changing landscape in which less and less forest remains to be cut, which makes it hard to draw clear conclusions about the relation between the level of education and the rate of deforestation.

Another controlling factor of deforestation in the study area was the desire to deter crop-damaging wild pests (eg bush pigs, common monkeys, baboons, giant forest hogs, and warthogs) and dangerous carnivores (eg lions, leopards, and hyenas). Indigenous people even encouraged migrants to clear the forests and their associated wildlife by allowing migrants to retain cleared land for themselves. Urgessa (2003) and Ango et al (2014) have reported that wildlife deterrence is also a key driver of deforestation in districts of the Jimma Zone in southwest Ethiopia. Deforestation for habitat destruction has led to a massive decrease in wild animals at the Haro Tatessa resettlement site in western Ethiopia (Ahmed 2005).

Deforestation in the study area is exacerbated by most local inhabitants (93% of indigenous households and 98% of migrant households) using firewood and charcoal as their primary sources of energy. The indigenous people perceived the migrants to have caused much of the deforestation because they were involved in large-scale production and sale of charcoal and firewood in nearby towns. Forest clearing for fuelwood and charcoal production has also been reported for other parts of Ethiopia (eg Decha in southwestern Ethiopia, Tadesse et al 2014; Afar region of northeastern Ethiopia, Tsegaye et al

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2010; northwestern Ethiopia, Limenih et al 2012; Central Rift Valley, Meshesha et al 2012). Moreover, increased demand for construction materials and wooden furniture in major towns was mentioned as being a crucial driver of forest depletion in the study area.

Unlike the migrant households, the indigenous residents practice some form of traditional forest management, partly because of cultural and religious norms. For example, it is a tradition to preserve tree species such as *Podocarpus falcatus, Ficus vasta,* and *Ekebergia capensis,* which are considered sacred trees (Hundera 2007). Removing these trees is strictly forbidden, because they serve different functions for prayers and rituals during times of drought, famine, and disease. Local residents usually gather under the shade of big sacred trees *(Adbar)* to pray to their gods (Hundera 2007; Tadesse et al 2014). The cultural and religious value of forests has also been reported for Zimbabwe (Byers et al 2001) and Mozambique (Virtanen 2002).

As a step toward the rehabilitation of depleted forest resources in the study area, local people have suggested organizing intensive reforestation or afforestation and awareness-raising programs. There is a general understanding about the need to plant trees, which is probably the result of the acute shortages of firewood, agricultural implements, and material for rural housing faced by the local inhabitants. This is in line with the findings of Urgessa (2003), who reported that 84% of the farmers in the Nada and Tiro Afeta Districts of the Jimma Zone wanted to actively participate in afforestation programs upon securing private tree ownership from the respective local governments.

Sources of error

In this study, maximal efforts were made to minimize the uncertainty of the collected data. Nevertheless, 2 sources of error remain: quantitative errors related to the assessment of deforestation rates and qualitative errors related to the interview procedures and their interpretation.

First, the use of low-resolution imagery and old panchromatic aerial photographs has limitations. Because it is hard to detect small deforestation patches on such imagery, the reported deforestation rates may be underestimated. Moreover, it is not possible to capture the gradual process of forest degradation caused by understory grazing and shortened shifting cultivation cycles, for example. An analysis of these processes would imply a systematic field-based forest inventory.

Second, there is uncertainty related to the survey and focus group data. Although many households were interviewed separately and several focus groups were organized independently, the results might be biased, because the perceptions of the interviewees did not necessarily correspond with reality. These perceptions may have been skewed further by the sociocultural relations between the 2 groups, who were competing for the same resources in the region. An in-depth anthropologic study could reveal to what extent these relations influence the perceptions that the different groups have of nature–society interactions.

Conclusions

People in Ethiopia have a long history of moving from environmentally fragile or degraded regions to more secure areas. The overpopulated and environmentally degraded northern and north-central highlands of the country have been major sources of migrants since the 1950s. These people have drifted toward, or been encouraged to resettle in, the wet, fertile, and relatively underutilized highlands and lowlands in the southern, western, southwestern, and northwestern parts of the country. For several reasons—including lack of planning, random selection of resettlement sites, and forced resettlement—most government-sponsored resettlement programs implemented in southwestern Ethiopia have failed to meet their objectives. As a result, severe deforestation and environmental degradation have occurred in the resettlement areas.

The series of resettlement programs implemented in the study area increased the pressure on forest resources by forcing smallholder farmers to intensify and expand their agricultural activities. Moreover, the traditional livelihood systems practiced by the indigenous people were largely replaced by the more intensive cereal farming practices of the migrants.

It is clear that the original low-productive indigenous farming system could never have fed the current population of the area, so a transition to a new farming system was necessary. However, the introduced farming system, based on oxen ploughing, is not sustainable, because it is not adapted to a region with tropical rains and results in severe land degradation and a decrease in the fertility of the land. This decrease in fertility forces the population to clear new land for arable farming, resulting in accelerated deforestation.

The findings from this study have policy-related implications at regional, national, and global scales. First, resettlement programs should be planned well ahead and in close consultation with different stakeholders at different levels to ensure sustainable use of natural resources with minimum environmental impacts. The implementation of resettlement programs should be closely monitored and regularly reevaluated to minimize the potential environmental impacts that migrants bring to the destination areas. Second, it is important to invest both time and resources in raising local awareness levels regarding the value of conserving forest resources and to provide newcomers with region-specific training programs for sustainable farming. Educational activities

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should be complemented by the drafting, implementation, and enforcement of regulations to protect common pool resources like the forests in southwestern Ethiopia. Third, the dependency of the local people on the remaining forest resources should be minimized by identifying and facilitating alternative livelihood strategies. Finally, it is important to use improved Earth observation technologies (eg time series of Landsat satellite images) to build forest datasets. These datasets should be used to continuously monitor the status of forest cover in the region and inform policy decisions.

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