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Impact of resettlement scheme on vegetation cover and its implications on conservation in Chewaka district of Ethiopia

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Abstract

Background: Resettlement has been conceived as a viable solution to the continual impoverishment and destitution of Ethiopian rural communities. However, it has considerable impacts on natural resources of the environment at destination areas. This study was carried out to evaluate impact of resettlement scheme on vegetation cover and its implications on conservation in Chewaka district of Ethiopia.

Methods: The study utilized ArcGIS10.3, ERDAS Imagine 9.1, Landsat imageries of 2000, 2009, 2018 and socio-economic data to analyze the LULC of the district. Normalized Difference Vegetation Index was employed to detect vegetation cover changes of the area. The study was conducted on the seven kebeles of Chewaka district and the total households of the sample kebeles are 3340. Through multistage sampling procedure a total of 384 households were selected from sample kebeles. Data were collected using questionnaires, GPS, interviews, focus group discussions and field observations. The collected data were analyzed both quantitatively and qualitatively.

Results: The results showed that Chewaka district has undergone substantial LULC change since population resettlement in the area. A rapid reduction of woodland (34.6%), forest (59.9%), grassland (50.5%) and bareland (46.8%) took place between 2000 and 2018, while built-up areas and cultivated lands have expanded at an average rate of 90.7 and 1515.7 ha/year respectively. The results of NDVI revealed that the extent of dense and sparse vegetation cover have decreased by 26.1% and 20.6% respectively, whereas non-vegetation cover has increased by 14,340.2 ha during the study period. It was found that rapid population growth following resettlement program, farmland and settlement expansion, deforestation, human-induced forest fire, lack of land use plan, unwise utilization and low management practices were the major factors that underpin the observed changes in the area.

Conclusions: Resettlement scheme has resulted in the depletion and dynamics of vegetation cover in Chewaka district. Therefore, the study suggests urgent attention on conservation of the remaining vegetation resources for sustainable utilization.

Keywords: Resettlement, NDVI, Vegetation cover dynamics, Land use/cover, Chewaka

Background

Resettlement is a phenomenon of population relocation from one geographical environment to the other either in a planned or spontaneous manner where adaptations

to various systems occur (Woube 2005). It is driven by a range of push and pull factors at area of origin and destination respectively (Tafesse 2007). The major push factors include development projects, natural disasters (drought, flood, earthquake), war, food insecurity and environmental degradation; while the pull factors include availability of unutilized land, good economic opportunities and conducive environment (Alemu 2015; Tafesse 2009; Tan 2008).

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Across the world, resettlement schemes have been undertaken for various purposes. They are often supposed to facilitate the implementation of a rural development policy (Evrard and Goudineau 2004). As noted by Stellmacher and Eguavoen (2011), resettlement initiatives have been employed by many African governments as a response for the mismatch of population numbers and environmental conditions. Likewise, Ethiopia has a long tradition of resettling people from drought prone and degraded areas to sparsely populated and less exploited corners of the country (Pankhurst 2009). In the country, there have been population resettlement practices during Imperial, Derg and EPRDF led governments (Mulugeta 2009; Rahmato 2003). Literature revealed that population pressures, extreme land degradation in the highland areas, land fragmentation, rampant unemployment, food insecurity, recurrent drought, poverty and famine has aggravated resettlement programs in Ethiopia since the Imperial period (Belay 2004; Tadesse 2009; Yonas et al. 2013; Zeleke and Mberengwa 2012).

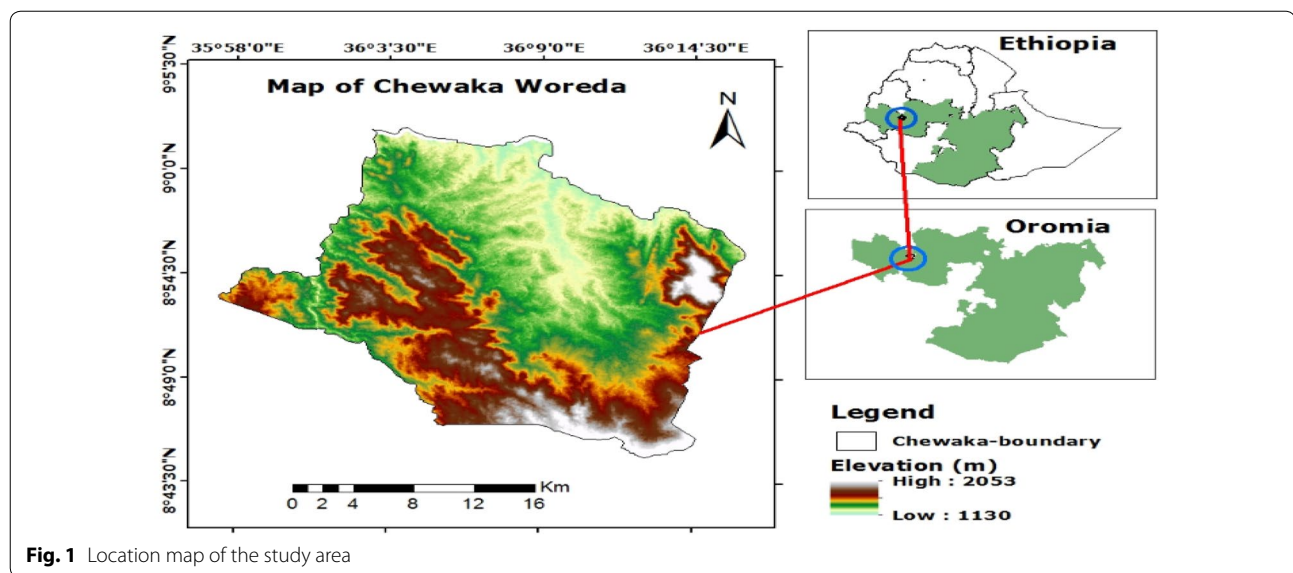
Resettlement has been considered as a viable development strategy to bring a lasting solution to the continual impoverishment and destitution of Ethiopian rural communities (Temesgen 2010). Despite of this fact, sources showed that resettlement can result in multifaceted impacts on the socioeconomic condition of the resettled communities as well as on environmental resources of the receiving areas (Dejene 2003; Getahun et al. 2017; Tan and Yao 2006; Vanclay 2017; Wilson 2019). Global studies on resettlement-environment interactions provide mixed outcomes. In some cases, despite population growth following resettlement, limited environmental degradation was observed; while in other cases, resettlement was associated with deforestation and degradation of the environment (Lemenih et al. 2014). Poorly planned resettlement schemes have adverse effects on bio-physical resources as well as on socio-economic aspects of the people (Woube 2005). In Ethiopia, population relocation causes ecological deterioration and severe resource depletion due to uncontrolled encroachment for settlement and farmland expansions (Berhanu et al. 2016; Wayessa and Nygren 2016). The emerging settlers' need of cultivable land and residential area intensifies the conversion of vegetated lands into cropping, grazing and settlement areas (Mulugeta and Woldesemait 2011). Most resettlement programs carried out in Ethiopia during the past and present exerts pressure on resources of the environment due to insignificant consideration for resource management, absence of feasibility studies as well as poor consultation with settlers and host communities (Pankhurst and Piguet 2004; Walle et al. 2011; Walo 2012). Thus, resource degradations are common in different resettlement areas of the country (Kassie et al. 2014).

Currently, Ethiopian government has carried out large scale intra-regional resettlement programs in four regional states of the country (Amhara, Oromia, Tigray and SNNPR) in 2003 to attain food security for 2.2 million chronically food insecure people (Hammond 2008). The programs are carried out in different areas of the four regions. Chewaka resettlement site is among these areas that hosted large number of settlers in Oromia Regional State. The government resettled massive number of people from drought-hit areas of East and West Hararge zones to Chewaka area as a response to the recurrent droughts, scarcity of farm lands and food insecurity problems (Jaleta et al. 2011; Taye and Mberengwa 2013). Prior to the resettlement program, the area was covered by dense forests, grasslands and woodland vegetations and it has immense potential of vegetation resources. However, resettlement was undertaken in the area without due consideration of the natural resource issues. Particularly, the program lacks Environmental Impact Assessment and management plan for the sustainable utilization of the resources. As a result, large areas which were under vegetation cover are cleared and converted to other land use/cover types. Besides, deforestation, uncontrolled farmland and settlement expansion, forest fire, unwise use and indiscriminate cutting of trees are the major observable problems in the area. Consequently, there has been vegetation cover dynamics or spatio-temporal vegetation cover change since the execution of population resettlement in the district. There are many studies that have been conducted in Ethiopia regarding resettlement issues. However, most of these studies were focused on the socio-economic outcomes, planning and implementation process, while the impact of resettlement on natural resources of the environment received little research attention (Adugna 2011; Belay 2004; Fratkin 2014; Pankhurst 2005; Woldeselassie 2004; Zeleke and Asfaw 2014). Similarly, despite the aforementioned problems in Chewaka district, less attention has been given on evaluating how the current intra-regional resettlement has impacted on vegetation resources of the area. The purpose of this study is, therefore, to analyze impact of resettlement scheme on vegetation cover and its implications for conservation using a combination of GIS and remote sensing techniques as well as socio-economic data to pinpoint appropriate management intervention strategies in the area.

Materials and methods

Description of the study area

The study was conducted in Chewaka district which is located in Buno Bedelle zone, Oromia Region of Ethiopia. The district covers a total area of 618.7 km² and it is about 552 km Southwest of Addis Ababa. Geographically,



it lies between $8^{\circ} 43' 30''$ N and $9^{\circ} 5' 30''$ N latitude and $35^{\circ} 58' 0''$ E to $36^{\circ} 14' 30''$ E longitude (Fig. 1). It was recognized as one administrative *woreda*¹ of Oromia Regional state since population resettlement in the area (Taye and Mberengwa 2013).

A diverse topographic condition which consists of undulating terrain, gentle sloping lowlands, gorges and small rounded hills characterizes the study site. Its altitude ranges between 1130 and 2053 m above mean sea level (Fig. 1). The district lies in moist Woina Dega (cool sub-humid) and Kolla (warm semi-arid) agro-ecological zones and experiences both high temperatures and rain-fall. It attains the maximum rain in the summer season (June, July and August) and small rainy season occurs from February to April. The dry season covers the remaining months of the year. The mean annual temperatures of the district range from 19.8 to 28.5 °C and the average annual rainfall varies between 800 and 1200 mm (NMSA 2018). According to Tolessa et al. (2019), the locality is mainly covered by Cambisols, Luvisols, Lithosols and it has huge potential of broad leaved dense forests, woodlands and grasslands. The dominant tree species grown in the area include; *Cordia africana*, *Ficus vasta*, *Albizia gummifera*, *Boswellia papyrifera*, *Podocarpus falcatus*, *Combretum terminalia* and *Acacia commiphora*. Currently, Chewaka district is inhabited by 96,446 people distributed within 28 *Kebeles*² (BZARDO 2018). Agriculture is the main economic activity and basis of livelihood for the people of the area. The farming system

is characterized by rain-fed, traditional, subsistence orientated and it is mixed which embraces both crop and livestock production. Major crops such as maize (*Zea mays*), sorghum (*Sorghum bicolor*), rice (*Oryza sativa*), sesame (*Sesamum indicum*) and soybean (*Glycine max*) are grown in the area. Besides, livestock production is an important means of livelihood next to crop production in the district.

Data sources and acquisition methods

Geospatial data acquisition

The study utilized three sets of satellite imageries; Landsat Thematic Mapper (TM) of 2000, Landsat Enhanced Thematic Mapper Plus (ETM+) of 2009 and 2018 for LULC change analysis of the study area. The three Landsat imageries, each with 30 m spatial resolution were downloaded free of charge from United States Geological Survey (USGS) websites (<https://earthexplorer.usgs.gov/>). The acquisition dates of imageries were made during dry and clear sky months (December to February) to reduce the effect of cloud cover and seasonal variation on the classification result that blight the quality of image. The year 2000 was taken as a reference for this study to know the status of vegetation cover prior to resettlement program because it was a year before resettlement for which cloud free satellite image is available. The 2009 image was used to have a clear picture on the rate of LULC changes during the study period. In addition, we preferred to use the year 2018 to analyze the current status of vegetation cover of the area. Toposheet of the study area with 1:50,000 scale was obtained from Ethiopian Geospatial Information Agency (EGIA) to support the classification and assure the rectification of imageries. Digital

¹ *Woreda* is an administrative unit in Ethiopia equivalent to a district.

² *Kebele* is the smallest administrative unit/structure in Ethiopia.

Table 1 Data types, sources and their description

Data type	Sensor	Path and row	Resolution (m)	Date of acquisition	Source
Landsat5	TM	170 and 054	30 × 30	27/12/2000	USGS
Landsat7	ETM+	170 and 054	30 × 30	26/01/2009	USGS
Landsat7	ETM+	170 and 054	30 × 30	05/02/2018	USGS
DEM	–	–	30 × 30	10/03/2018	EGIA
Toposheet	–	–	1:50,000	10/03/2018	EGIA

Table 2 Distribution of total and sample households in the sample kebeles. Source: field survey (2018)

Site no	Sample kebeles	Household size of sample kebeles			Sample size		
		M	F	Total	M	F	Total
1	Chokorsa	449	123	572	52	14	66
2	Gudure	385	96	481	44	11	55
3	Waltasis	410	97	507	47	11	58
4	Jagan	368	117	485	42	14	56
5	Walda Jalala	193	78	271	22	9	31
6	Tokkuma Harar	427	134	561	49	16	65
7	Urji Oromiya	369	94	463	42	11	53
Total	7	2601	739	3340	298	86	384

Elevation Model (DEM) was also obtained from EGIA to extract terrain attributes (Table 1). Ground control points have been taken during field observation by using Global Positioning System (GPS) to aid different steps of image processing and classification for change detection. Furthermore, GIS and remote sensing techniques were employed to map, quantify and analyze LULC changes of the area. Various Softwares such as ERDAS Imagine 9.1 and ArcGIS 10.3 are used for image processing, classification, mapping and analysis purpose.

Socio-economic data collection

In this study, multistage sampling procedure was used to select the study area and the sample households. In the first stage, Chewaka district was purposively selected as a research site because it is the largest resettlement scheme that hosts huge number of settlers in Southwestern Ethiopia. In the second stage, seven kebeles (namely Chokorsa, Gudure, Waltasis, Jagan, Walda Jalala, Tokkuma Harar and Urji Oromia), where the problem of vegetation degradation is more critical, are purposively selected from the seven resettlement sub-sites of the district (i.e. Total kebeles of the district were grouped according to the existing resettlement sub-sites of the area and from each sub-sites one kebele was selected). In the third stage, systematic random sampling technique was employed to

obtain respondents from the available lists of each sample kebeles. This sampling technique can be used when the size of population is very large due to its simplicity, less costly and ease of implementation (Walliman 2006). The total household heads of the sample kebeles are 3340. In order to determine sample size for this study, we employed the following formula (Kothari 1990).

$$n = \frac{P * (1 - P) * Z^2}{e^2} \tag{1}$$

where *n* = sample size; *P* = estimated proportion of respondents. As the proportion is not known, 0.5 was used as *p* value to obtain maximum number of the respondents. *Z* = the number of standard error corresponding to 95% confidence interval which is 1.96. *e* = margin of error that the researchers tolerates is 0.05.

Therefore, the total numbers of sample size were 384.

$$n = \frac{0.5 * (1 - 0.5) * (1.96)^2}{(0.05)^2} = \underline{384}$$

Accordingly, a total of 384 households were selected and the selection started randomly from the list of households which proceeds at every 9th interval until the required sample size reached. The size of interval for selection was determined using the formula (*k* = *N*/*n*) where; *N* is the total population, *n* is the required number of sample and *k* is the size of interval for selection (Mota et al. 2019). Thus, households were selected proportionally from sample kebeles for survey questionnaire (Table 2). The questionnaires were composed of both open and close-ended types to collect reliable data about the impact of resettlement on vegetation cover, the existing land use/cover types and socio-economic condition of the respondents as well as drivers of vegetation cover change in the area. The questionnaires were administered by researchers and trained enumerators. Two focus group discussions (FGDs) were conducted to get participants view concerning the issue understudy. As suggested by Deribsa (2018), the participants in FGDs can range from 6 to 12 persons with similar background. Discussions were carried out with seven model farmers (one model farmer from each sample kebele) and six

Table 3 Land use/cover types of the study area and their description

LULC type	Description
Forest land	A vegetation type covered with dense growth of trees that formed nearly closed canopies rising up to 30 m
Woodland	Land areas covered with woody plants mixed with shrubs, bushes, and grasses
Grassland	Areas of land predominantly covered with grasses, forbs, grassy areas
Built-up area	The land covered with settlement areas in rural or urban places
Cultivated land	A land area ploughed/prepared for growing various crops/cultivated fields
Bare land	Areas that have no vegetation cover consisting of eroded landscapes and exposed rocks

natural resource experts of the district from the office of agricultural and rural development, natural resource management and environmental protection as well as rural land administration and management (i.e. two individuals from each office). The participants were selected purposively because we believed that they had better and more detail information about the issue under study and the discussions were facilitated by the researchers. In-depth key informant interviews were also conducted with development agents (one development agents from each sample kebele), managers of each sample kebele as well as two individuals from woreda and zonal administration offices to get detail information about the issue under investigation. Furthermore, field observation was also conducted through transect walk with development agents by the aid of visual photographs to crosscheck data collected via other data collection instruments. To substantiate the analysis, supplementary data that are relevant to the study were collected from published and unpublished documents. The data collected from various sources were analyzed both qualitatively and quantitatively. Statistical softwares such as SPSS version 20 was used for socio-economic data analysis.

Satellite image processing and analysis

Time series Landsat imageries of 2000, 2009 and 2018 were imported to ERDAS Imagine 9.1 image processing software. Image pre-processing, classification, accuracy assessment and change detection were carried out on the imageries (Fig. 2).

Image pre-processing

Prior to the main data analysis and extraction of information, image pre-processing such as geometric and radiometric corrections, image enhancement and sub-setting were applied on the raw imageries. Satellite imageries were geometrically corrected using geo-referenced

toposheet of the study area with scale of 1:50,000 and re-projected to the World Geodetic System (WGS) 1984 datum, Universal Transverse Mercator (UTM) projection, Zone 37 N to ensure consistency between datasets during analysis. Radiometric corrections such as haze reduction/dark object subtractions were executed as well. Image enhancement was also carried out using histogram equalization to improve the visual interpretability of an image. As stated by Lillesand et al. (2008), image enhancement improves the appearance of imagery and makes analysis better. In addition, image sub-setting was conducted to cut out unnecessary data from the file and increase the data-processing speed. The imageries were clipped with the boundary of the study area for further processing.

Image classification

In this study, both unsupervised and supervised image classification techniques were performed by using ERDAS Imagine 9.1 software. First unsupervised classification was applied to get insight about the general LULC classes of the study area. Then, supervised classification using maximum likelihood algorithm was carried out to categorize the images by taking training points which were defined based on the results of unsupervised classification and ground truth points. The land units of the study area were fixed for the purpose of mapping on the basis of information obtained from the field visits, discussions with farmers and land resource management experts of the district. The major land classes were: forest land, woodland, cultivated land, built-up area, grassland and bareland (Table 3). Thus, the LULC maps of the 3 years (2000, 2009 and 2018) were produced from the satellite imageries.

Accuracy assessment

In order to verify the reliability of produced classification, accuracy assessment was done using confusion/error matrix. An error matrix is a square array of rows and columns that indicates the nature of classification error by comparing the proportion of correctly classified image with reference data (Congalton 1991). In this study, reference data were collected during field work using Global Positioning System (GPS) and the reference points were independent of the ground truths that are used in the classification scheme. About 800 GCPs were collected from the field for accuracy assessment. Accordingly, the overall accuracy, Kappa coefficient, producer's accuracy and user's accuracy were computed from the confusion matrix (Foody 2002). Besides, Google Earth was also used to aid the validation process. In principle, the output maps have to meet the minimum of 85%

accuracy (Anderson 1976). According to Congalton and Green (2009), the overall accuracy was computed by dividing the number of correct values in the diagonals of the matrix to total number of values taken as a reference point; producer’s accuracy was derived by dividing the number of correct pixels in one class divided by the total number of pixels as derived from reference data; user’s accuracy was calculated by dividing correct classified pixels by the total number of pixels and Kappa coefficient, which measures the agreement between the classification map and the reference data, were calculated as per Bishop and Fienberg (2007) using the following equation;

$$K = \frac{N \sum_{i=1}^r x_{ii} - \sum_{i=1}^r (x_{i+})(x_{+i})}{N^2 - \sum_{i=1}^r (x_{i+})(x_{+i})} \tag{2}$$

where K is Kappa coefficient, r is the number of rows in the matrix, x_{ii} is the number of observations in row i and column i (the diagonal elements), x_{i+} are the marginal totals of row i , x_{+i} are the marginal totals column i , and N is the total number of observations.

Change detection

To analyze the patterns of LULC change, post-classification comparison approach was performed. This technique provides the detailed “from-to” information and minimizes the possible effects of atmospheric variations and sensor differences (Lu et al. 2004). Therefore, Landsat imageries of the three reference years were first independently classified. Then, the classified imageries were compared and change statistics were computed by comparing image values of one data set with the corresponding values of the second data set. The comparison values were summarized and presented in terms of area change in hectares, percentages and rate of change. The extent of area change (total change) for each LULC class was obtained by subtracting the area of initial year (oldest date) from the value of recent date (final year) of the study period. According to Kindu et al. (2013), the percentage and rate of land use/cover change can be calculated using the following equation:

$$\% \Delta A = 100 \left(\frac{A_{t2} - A_{t1}}{A_{t1}} \right) \tag{3}$$

where $\% \Delta A$ is percent change in the area of a land use type between initial time (t_1) and final time (t_2); A_{t1} is the area of the land use at t_1 time; A_{t2} is the area of the same type in t_2 time.

$$\text{Rate of change (ha/year)} = (A - B)/T \tag{4}$$

where A is area of LULC (ha) in time 2; B is area of LULC (ha) in time 1; T is time interval between A and B in

years. Furthermore, to vividly understand which cover types goes to where during the study period, land cover conversion matrix was analyzed. In the change matrix, the column of the table represents the initial year and the row represents the final year. Whereas, the diagonal values represent the unchanged portions of each cover classes.

Normalized Difference Vegetation Index analysis

Normalized Difference Vegetation Index (NDVI) is the most widely used technique that differentiates vegetation resource from other land cover classes based on vegetation reflectance properties. It shows vegetation abundance distribution, degradation status and coverage (Pettorelli et al. 2005; Sun et al. 2011). The value of NDVI ranges from -1 to $+1$. Non-vegetation (barren rock, sand, water) typically has NDVI value 0.1 or less; sparse vegetation (shrubs, grasslands) values are between 0.2 and 0.5 and dense vegetation values are over 0.5 (Arulbalaji and Gurugnanam 2014; Holben 1986). In this study, Landsat imageries of 2000, 2009 and 2018 were used to extract NDVI values. The values were reclassified as non-vegetation, sparse vegetation and dense vegetation based on NDVI results to analyze vegetation cover changes of the area. According to Gandhi et al. (2015), NDVI can be calculated as follow:

$$NDVI = (NIR - R)/(NIR + R) \tag{5}$$

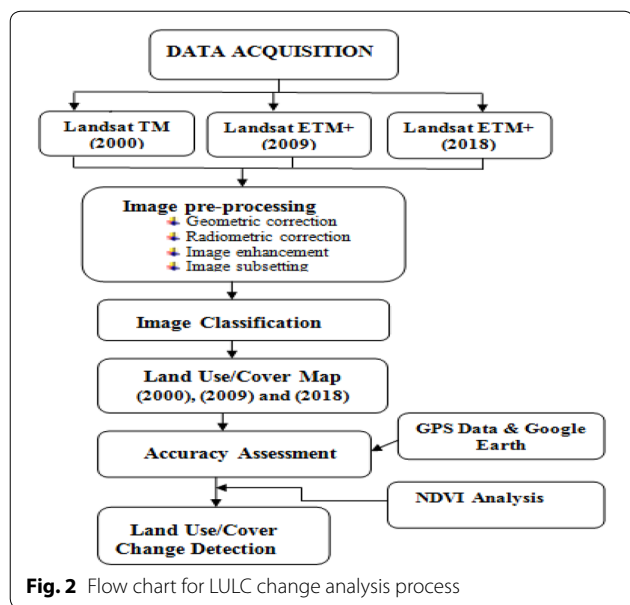
where NDVI is Normalized Difference Vegetation Index; NIR is Near Infrared band reflectance at 0.76–0.9 μm and R is Red band reflectance at 0.63–0.69 μm .

Results

Status of land use/cover in Chewaka district pre and post resettlement

The land use/cover status of Chewaka district was mapped for the year 2000, 2009 and 2018 to analyze the patterns of change that occurred in the area (Fig. 3 and Table 4).

The result of satellite image analysis showed that in the year 2000, the district was covered by forest, woodland, grassland and bareland. There was neither settlement nor cultivated land prior to the 2003 resettlement program in the area. The socio-economic survey also confirmed that land uses of various types like cultivated lands and built-up areas are emerged in 2003. Hence, six land use/cover types were identified on the 2009 and 2018 satellite imageries of Chewaka district. The detail land use/cover status of the area is presented as follows;



Woodland

It was the dominant land cover type which constitutes 45% (27,647.97 ha) of the total area in 2000. The woodland cover had shown dramatic decrease to 41.2% (25,483.9 ha) in 2009 and 29% (18,088.5 ha) in 2018. The district has lost 34.6% of woodland at an average rate of 531 ha/year between 2000 and 2018. The increasing demand for construction, firewood consumption and agricultural land expansion has contributed to the depletion of woodland cover.

Grassland

The result indicated that grassland covered 17% of the total area in the year 2000. However, its cover was declined to 11.9% in 2009 and 9% in 2018. This land cover was reduced by 50.5% at an average rate of 303 ha/year during the study period. In the district, grassland is a potential area for agricultural activities of the people and the reduction of its cover could be attributed to the expansion of cultivated lands at the expense of this cover class.

Forest land

A continuous decline of forest cover was observed over the study period. Of the total area of the district in 2000, forest land constituted about 36%. In 2009 and 2018, it accounted for 15.2% and 14% respectively, of the total area of the study site (Table 4). During the study period, forest land showed reduction in coverage by 59.9% at an average rate of 745.2 ha/year. The depletion of forest cover occurred due to the destruction of natural forests for farm plots, settlement expansion and construction materials.

Bareland

During the study period, bareland covers the smallest portion among other land use/cover types. Land covered by bareland was 1042.73 ha, accounting for 2% of the total area in 2000. Its cover has reduced to 1.2% (721.62 ha) in 2009 and 1% (555.2 ha) in 2018. The coverage of bareland has decreased by 46.8% at an average rate of 27 ha/year between 2000 and 2018 mainly due to the expansion of built-up area at the expense of bareland.

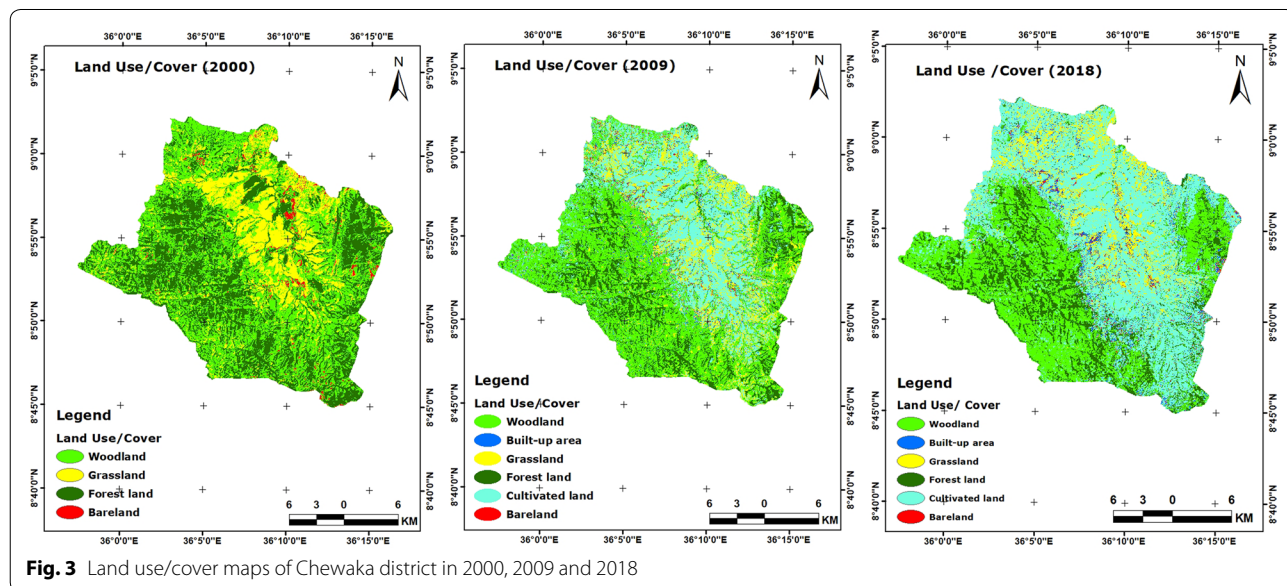


Table 4 Comparison of LULC types between 2000 and 2018. Source: Computed from satellite imageries of 2000, 2009 and 2018

LULC types	2000		2009		2018		Change between (2000–2018)		
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Rate of change (ha/year)
Forest land	22,368.95	36	9422.46	15.2	8954.7	14	− 13,414.25	− 59.97	− 745.2
Woodland	27,647.97	45	25,483.96	41.2	18,088.5	29	− 9559.5	− 34.6	− 531.0
Grassland	10,808.23	17	7372.8	11.9	5353.3	9	− 5454.9	− 50.5	− 303.0
Bareland	1042.73	2	721.62	1.2	555.2	1	− 487.5	− 46.8	− 27.0
Built-up area	–	–	1566.09	2.5	1633.0	3	+ 1633	–	+ 90.7
Cultivated land	–	–	17,300.97	28.0	27,283.2	44	+ 27,283.2	–	+ 1515.7
Total	61,867.9	100	61,867.9	100	61,867.9	100			

Cultivated land

This LULC showed drastic expansion as compared to other cover classes during the study period. There was no cultivated land prior to the execution of resettlement program in the area. However, since resettlement program, the demand for food crop production has resulted in the expansion of cultivated land at an average rate of 1515.7 ha/year between 2000 and 2018. The extent of its cover has increased to 28% (17,300.97 ha) in 2009 and 44% (27,283.3 ha) in 2018. Currently, it covers the largest portion of the area in the district.

Built-up area

The result of this study showed that resettlement program has led to the expansion of built-up areas in the study site. Prior to the 2003 resettlement program, there was no settlement in Chewaka area. However, the government resettled large number of settlers from East and West Hararge zone to the area and built-up areas were expanded by clearing forests, woodlands and grasslands. The extent of built-up area cover has increased to 2.5% (1566.09 ha) in 2009 and 3% (1633 ha) in 2018. Its cover has increased at the rate of 90.7 ha/year during 2000–2018. The land use/cover change matrix was also analyzed to show which cover types goes to where between 2000 and 2018 (Fig. 4 and Table 5).

The result of the study revealed that there was remarkable conversion of areas once covered with forests, woodlands and grasslands to cultivated lands and built-up areas. For instance, the total forest cover of the district was 22, 368.95 ha in 2000. However, the extent of forest cover has shrunk to 8954.7 ha in 2018 due to deforestation and conversion to other cover types. From total forest cover, about 6939.7 ha remained as unchanged, 248 ha changed to built-up area, 6004.8 ha changed to cultivated land, 8472.8 ha converted to woodland, 600.8 ha to grass land and 102.8 ha changed to bareland during the study period. The greatest share of the forest land was converted to the woodland and cultivated area. Similarly, about 13,903.1 ha and 712.3 ha of woodland was converted to cultivated lands and built-up areas respectively (Table 5). The expansion of cultivated lands and built-up areas largely contributed to the dwindling of forests, woodlands and grasslands of the area at alarming rate.

Accuracy assessment result

Classification accuracy assessment was done for the classified imageries using error matrix. The producer’s, user’s and overall accuracy as well as the kappa statistics were computed.

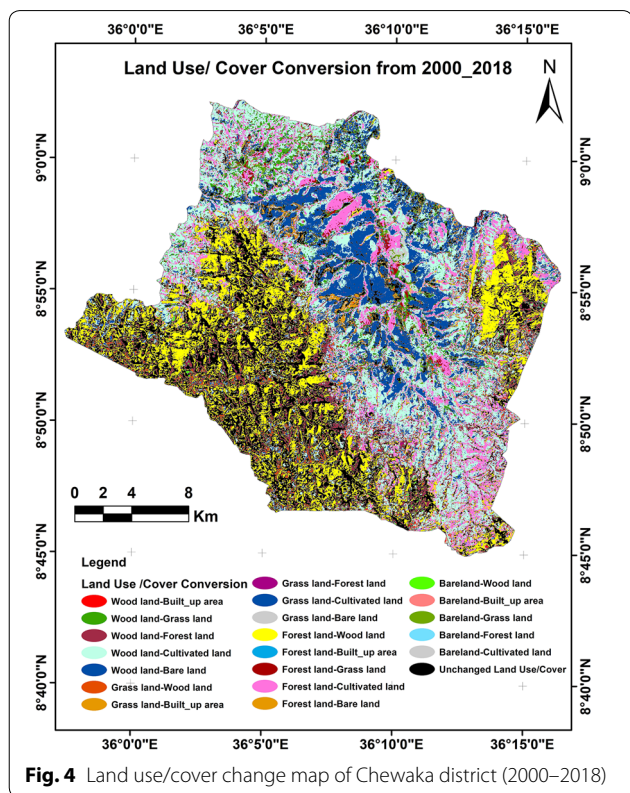


Fig. 4 Land use/cover change map of Chewaka district (2000–2018)

Table 5 Land use/cover change matrix for Chewaka district (2000–2018)

LULC classes		LULC (2000)				
		Forest land	Woodland	Grassland	Bareland	Total area
LULC (2018)	Forest land	(6939.7)	1918.6	71.2	25.1	8954.7
	Woodland	8472.8	(8881.7)	643.6	90.4	18,088.5
	Grassland	600.8	1992.4	(2560.3)	199.8	5353.3
	Bareland	102.8	239.8	169.9	(42.6)	555.2
	Built-up area	248	712.3	598.8	73.9	1633
	Cultivated land	6004.8	13,903.1	6764.5	610.8	27,283.2
	Total area	22,368.95	27,647.97	10,808.23	1042.73	61,867.9

Numbers in the parenthesis indicates the unchanged values in land use/cover

Table 6 LULC types and accuracy assessment result of the classified imageries

LULC types	2000		2009		2018	
	PA (%)	UA (%)	PA (%)	UA (%)	PA (%)	UA (%)
Forest land	88.46	92.0	78.95	90.0	93.88	92.0
Woodland	91.67	88.0	97.78	88.0	91.67	88.0
Grassland	84.0	84.0	95.83	92.0	86.54	90.0
Bareland	84.0	84.0	89.36	84.0	89.80	88.0
Built-up area	–	–	84.31	86.0	86.54	90.0
Cultivated land	–	–	86.54	90.0	88.0	88.0
Overall accuracy	87.00%		88.33%		89.33%	
Kappa coefficient	0.8267		0.8600		0.8720	

PA producer's accuracy, UA user's accuracy

As can be seen from Table 6, the overall classification accuracy assessment and kappa statistics result for the year 2000, 2009 and 2018 were 87.00%, 0.82; 88.33%, 0.86 and 89.33%, 0.87 respectively. This showed that all maps meet the recommended minimum 85% accuracy and there is a strong agreement between the classified land use/cover classes and the reference data.

Resettlement and vegetation cover change in Chewaka district

In 2003, a large-scale national resettlement program was carried out by the government in Chewaka district. Following this scheme, the area was characterized by remarkable changes and adverse impacts are induced by resettlers on vegetation resources of the area. To detect the dynamics of vegetation cover, Normalized Difference Vegetation Index (NDVI) analysis was carried out for the district using Landsat imageries of 2000, 2009 and 2018 (Fig. 5 and Table 7).

The results of NDVI indicated that there have been significant changes of vegetation cover in the study area as shown in Fig. 5 and Table 7. Dense vegetation showed continuous decline in the entire period considered. In 2000, about 54.7% of the district area was under dense

vegetation cover. However, the extent of its cover has reduced to 42.9% in 2009 and 40.5% in 2018. During the study period, the district has lost 26.1% (8814.6 ha) of the dense vegetation. The decline in the area coverage of dense vegetation was attributed to its conversion to other LULC. Similarly, sparse vegetation covered 43.4% of the total area in 2000, but sharply decreased to 35.5% in 2009 and 34.5% in 2018. Sparse vegetation showed reduction in coverage by 20.6% (5525.6 ha) between 2000 and 2018. On the contrary, the areal extent of non-vegetation cover has increased drastically from 1.9% in 2000 to 21.6% and 25% in 2009 and 2018 respectively.

Socioeconomic characteristics of the respondents

The survey result indicated that the sample population was composed of 78% male and 22% female respondents. The age of the households ranges from 20 to 78 years and the mean age being 46.8 years. Majority (83%) of the respondents were found in the age category of 15–64. Those respondents with age group greater than 64 years account for 17%. Nearly 72% of the respondents were illiterate and the remaining 28% were literate. Most of the households (75%) had 1–2 ha land sizes and only 19% had greater than 2 ha. About 7% of respondents had less than

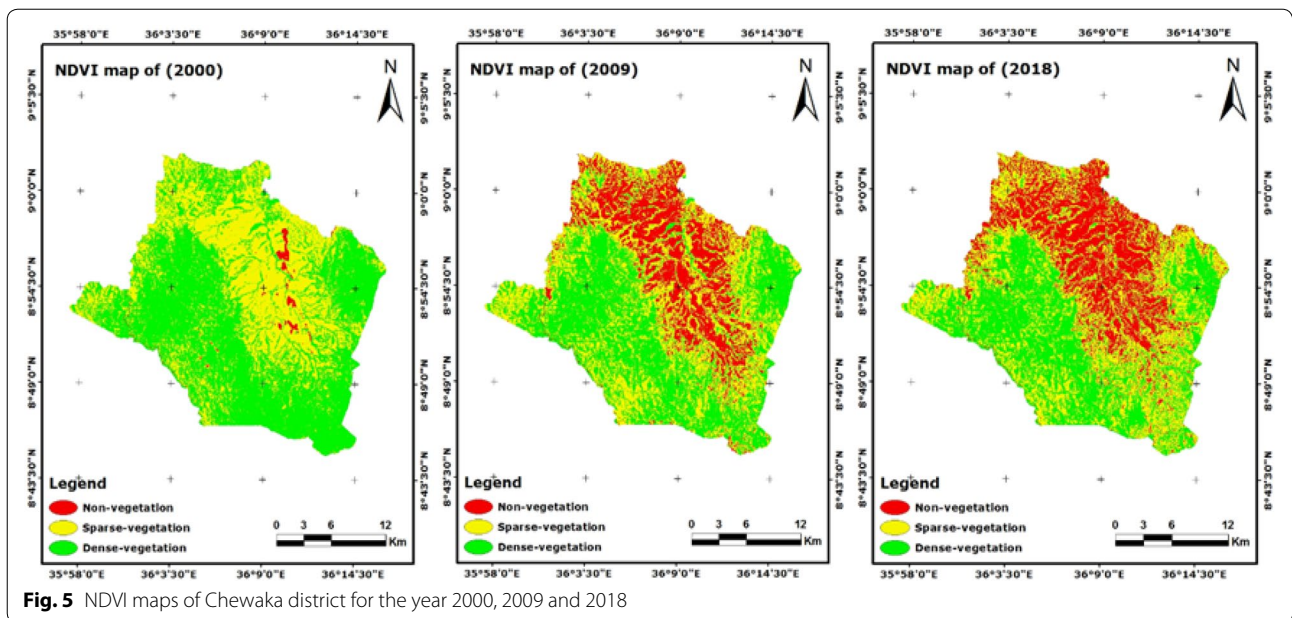


Fig. 5 NDVI maps of Chewaka district for the year 2000, 2009 and 2018

Table 7 Status of vegetation cover in Chewaka district between 2000 and 2018. Source: Computed from satellite imageries of 2000, 2009 and 2018

Land cover types	2000		2009		2018		2000–2018
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Total loss or gain
Non vegetation	1175.5	1.9	13,391.1	21.6	15,515.7	25	+ 14,340.2
Sparse vegetation	26,850.7	43.4	21,966.02	35.5	21,325.1	34.5	– 5525.6
Dense vegetation	33,841.7	54.7	26,510.78	42.9	25,027.1	40.5	– 8814.6
Total	61,867.9	100	61,867.9	100	61,867.9	100	

1 ha land size and the overall average land size was 1.4 ha per household (Table 8).

Major drivers of vegetation cover change in Chewaka district

This study explores the main drivers of vegetation cover change that are associated with the implementation of resettlement scheme in Chewaka district of Ethiopia. The study found that resettlement and population growth (91.4%), farmland and settlement expansion (87.5%), deforestation (68.5%), human-induced forest fire (59.6%), unwise utilization and low management practices (72.9%) were identified as the major factors attributed to the dynamics of vegetation cover in the study site (Table 9).

(I) Resettlement and population growth

Nowadays, the most uncontrolled changes in natural land covers are resulting from demographic factors such

as population growth. Change in population size affects the resources of the environment particularly, in rural areas where livelihood of the people depends on the natural resources. In Chewaka district, resettlement and population growth is identified as one of the major drivers of vegetation cover change. The data obtained from BZARDO (2018) indicated that population of the district was increased from 60,000 in 2003 to 96, 446 in 2018. Between 2003 and 2018, population of the district alarmingly increased by 61% at average annual growth rate of 4.1%, while the average annual growth rate for Ethiopia was 2.6% (CSA 2013). This shows the growth rate of the district was higher than the national average. Population density of the district also increased from 97 person/km² in 2003 to 156 person/km² in 2018 (Table 10). Hence, the district is experiencing rapid population growth and high population density which induces increased demand for resources and exacerbates the rate of resource depletion in the area.

Table 8 Characteristics of the sample population. Source: Survey data (2018)

Attributes	Categories of attributes	Frequency	(%)	Remark
Sex	Female	86	22.4	–
	Male	298	77.6	
Age	< 15	–	–	Min: 20
	15–64	318	82.8	Mean: 46.8
	> 64	66	17.2	Max: 78
Educational status	Illiterate	278	72.4	–
	Literate	106	27.6	
Land holding size (ha)	< 1	25	6.5	Min: 0.5 ha
	1–2	287	74.7	Mean: 1.4 ha
	> 2	72	18.8	Max: 3 ha

Table 9 Households’ perceived drivers of vegetation cover change in Chewaka district

Perceived drivers/causes	% of respondents (n = 384)
Farmland and settlement expansion	87.5
Resettlement and population growth	91.4
Human-induced forest fire	59.6
Deforestation	68.5
Unwise utilization and low management practices	72.9
Overgrazing	18.8

The total is not 100 due to multiple options

The result showed that population of the district drastically increases due to government resettlement program and influx of migrants from surrounding areas. The government resettled about 60,000 people from east and west Hararge zones to the area in 2003 as a response to food insecurity and land scarcity problem (Berhanu 2007). Consequently, massive population resettlement and subsequent increase in the demands for construction materials, fuel wood, settlement and land for cultivation has resulted in altering vegetation cover of the area through destruction of woodlands, forests and grasslands.

(II) Farmland and settlement expansion

Human actions are altering the natural environment and its resources at unprecedented magnitudes and spatial scales. In the study area, evidence from local informants indicated that there was no settlement and cultivated land before 2003. However, cultivated lands and built-up areas have been drastically increased with a concomitant shrinkage in the area coverage of woodlands, forests and

Table 10 Population change in Chewaka district from (2000–2018). Source: BZARDO (2018)

No	Year	Population size	Population density (population/km ²)
1	2000	^a	^a
2	2003	60,000	97
3	2010	87,696	142
4	2018	96,446	156

^a Indicates there was no population that resides in the area in the year 2000

grasslands after resettlement program in the area. Satellite image analysis showed that about 6004.8 ha of forest lands and 13,903.1 ha of woodlands were converted to cultivated lands. Similarly, about 248 ha of forest lands and 712.3 ha of woodlands were changed to built-up areas (Table 5). The field observations also indicated that settlers are clearing vegetation resources to expand their farm plots for cereal crops (maize, rice, sorghum) and cash crop production/Chat plantation (Fig. 6). Thus, farmland extensification and settlement expansion has depleted vegetation cover of the area.

(III) Deforestation

In many parts of Ethiopia, the extent of forest cover has reduced through time due to continuous deforestation (FAO 2010). Likewise, it is one of the major threats to the forests and woodlands of Chewaka district due to ongoing population growth. The clearing of land for cultivation, growing demand for household energy and construction materials has aggravated the problem of deforestation in the district.

The survey result showed that resettlers excessively exploited fuel wood and charcoal entirely from the natural forests and woodlands of the area. Majority of the respondents (88.8%) used fuel wood and charcoal as the major sources of energy due to lack of alternative energy sources, while 8.3% and 2.9% of the respondents reported that they used crop residue and others (kerosene, electricity) as a source of energy respectively Table 11. Focus group discussion participants mentioned that the landless and jobless youths of the district were engaged in fuel wood extraction and charcoal production for sale to fulfill their livelihood requirements which resulted in the depletion of vegetation cover in the area.

(IV) Unwise utilization and low management practices

In rural areas of Ethiopia, over 85% of the people depend on natural resources of the environment for their livelihood (Dejene 2003). Despite of this fact, resource degradation is a common phenomenon in many parts of the



Fig. 6 Farmland expansion (rice cultivation and chat plantation) in Chewaka district, field photo (2018)

Table 11 Source of energy for the sample respondents. Source: Survey data (2018)

Source of energy	Frequency	Percent
Fuel wood and charcoal	341	88.8
Animal dung	–	–
Crop residue	32	8.3
Others	11	2.9
Total	384	100

country owing unwise utilization and low management practices. Similarly, vegetation resource degradation is a major observable problem in Chewaka district because of little effort to manage and wisely utilize the resources of the environment by local communities.

Large proportion of respondents (81%) reported that their participation in vegetation resources management is low, while 16.9% and 2.1% of the respondents have medium and high participation respectively (Table 12). Evidence obtained from sample households revealed that lack of a sense of ownership, absence of alternative employment opportunity to generate additional income as well as lack of awareness about the long term effects of resource degradations were the major factors responsible for the low performance of conservation activities. This shows high dependence of resettlers’ livelihood on agriculture has destructed the forests and woodlands of the area to expand farmlands. The result of focus group discussions showed that vegetation resources are openly accessed by local communities and there is lack of ownership rights (tenure security) for the residents which affect their utilization and management decisions. Furthermore, they mentioned that there is weak institutional

Table 12 Perceived status of households’ participation in vegetation resource management

Status of participation	Frequency	Percent
Low	311	81.0
Medium	65	16.9
High	8	2.1
Total	384	100

setup and lack of coordination among various stakeholders to mobilize local community participation for sustainable management of the resources. The key informants also stated that Environmental Impact Assessment was not carried out before resettlement program and there is lack of proper land use plan in the area which contributed to the degradation of vegetation resources. In the area, absence of land use plan is characterized by uncontrolled encroachment into vegetated lands for settlement and agriculture. Hence, population pressures compounded with few conservation efforts jeopardized the sustainability of vegetation resources of the area (Fig. 7).

(V) Forest fire

In Ethiopia, forest fire is one of the major causes for the ruthless destruction of vegetation resources during the past and present (Kidane et al. 2012). Likewise, human-induced fire incidence has threatened the forest and woodland covers in Chewaka district.

The study result indicated that the local people set fire on the forests and woodlands of the area to expand agricultural lands. Majority of the respondents (83.3%) replied that land clearing for cultivation is the main cause of forest



Fig. 7 Vegetation resource destruction in Chewaka district, field photo (2018)

fire in the area, while 12.8% and 3.9% of the respondents reported that the cause of fire incidence is associated with charcoal production and honey extraction from the forest respectively (Table 13). Discussions with natural resource expertise of the district confirmed that forest fire that occurs frequently in the study area damages a large area of vegetation cover every year to expand farm plots.

Discussion

Findings of this study revealed that during the study period (2000–2018), six land use/cover types namely; woodlands, forests, grasslands, barelands, cultivated lands and built-up areas were identified in Chewaka district. The district has undergone substantial land use/cover changes due to the implementation of resettlement program in the area. A rapid reduction of woodland (34.6%), forest (59.9%), grassland (50.5%) and bareland (46.8%) took place between 2000 and 2018, whereas built-up areas and cultivated lands have expanded at an average rate of 90.7 and 1515.7 ha/year respectively. The survey result showed that the increasing demand for farm plots; firewood and charcoal production, construction materials and settlement areas have resulted in changing the land use/cover of the area. In agreement to this finding, a significant loss of woodland cover was reported by Alemu et al. (2015) in Northwestern lowlands of Ethiopia (Metema, Kafta-Humera and Sherkole) during 1985–2010. Asmamaw et al. (2011) also found a major decline in grassland cover in Gerado catchment, Northeastern Ethiopia between 1980 and 2006 at 1.17% annual rate. In contrast, Shiferaw and Singh (2011) reported a slight expansion in grassland coverage in Borena woreda, South Wello highlands of Ethiopia during 1985–2003 due to the

conversion of forest and shrub land to grassland. Study conducted by Hassen and Assen (2017) in Gelda catchment, Northwest highlands of Ethiopia found the decline in forest cover by 83.8% between 1957 and 2014. On the contrary, Tesfaye et al. (2014) reported increment in forest cover between 1986 and 2008 in Gilgel Tekeze catchment, Northern Ethiopia mainly due to tree plantation campaign undertaken in the area.

The emergence of cultivated lands and built-up areas were found to be the result of 2003 resettlement program in Chewaka district. During the study period, the extent of cultivated lands and built-up areas were expanded attributed to the demand for attaining food crops and more settlement area. Consistent with this finding, Gashaw et al. (2014) in Dera district of Ethiopia found increment in cultivated areas in the last 26 years to feed the growing population of the area. Similarly, Agidew and Singh (2017) in Teleyayen sub-watershed of North-eastern Ethiopia found the expansion of built-up area at the rate of 62.9 ha/year during 1973–2015. The study showed that Chewaka district was dominantly covered by dense forests, woodlands and grasslands just before the

Table 13 Causes of forest fire in Chewaka district. Source: Survey data (2018)

Causes of forest fire	Frequency	Percent
Charcoal production	49	12.8
Land clearing for cultivation	320	83.3
Honey extraction from the forest	15	3.9
Others	–	–
Total	384	100

onset of resettlement program. However, significant conversions from vegetation cover to cultivated lands and built-up areas were observed after resettlement which devastated vegetation cover of the area. In agreement to this finding, previous studies conducted by Denboba (2005) in Shomba and Michity resettlement areas in Kafa zone, Southwestern Ethiopia; Mulugeta and Woldesemait (2011) in Nonno resettlement sites, Central Ethiopia and Yonas et al. (2013) in the Meinit-Shasha district in Southwestern Ethiopia reported the occurrence of considerable cover dynamics due to resettlement programs. Minale and Rao (2012) in Gilgel Abbay catchment, Northwestern Ethiopia also found that agricultural lands and settlement areas were expanded at the expense of forests, riparian vegetation and grasslands during 1973–2008. Similarly, Gebrehiwot et al. (2010) in Koga watershed at the headwaters of the Blue Nile Basin; Kindu et al. (2013) in Munessa Shashemene landscape of the Ethiopian highlands; Gebrelibanos and Assen (2015) in Hirni watershed of Northern Ethiopia; Molla (2015) in Arsi Negele District, Central Rift Valley Region of Ethiopia reported that the decline of grassland and natural vegetation including forests and woodlands have occurred due to conversion to croplands, grazing lands and human settlement areas.

The results of Normalized Difference Vegetation Index (NDVI) indicated that resettlement program in the district has exacerbated the depletion of vegetation cover. The extent of dense and sparse vegetation cover have decreased by 26.1% and 20.6% respectively during 2000–2018. On the other hand, non-vegetation cover has increased by 14,340.2 ha. This implies vegetation cover was decreased and non-vegetated areas increased during the study period mainly due to the increased rate of cultivated lands and built-up areas at expense of vegetated lands. Consistent with this result, study conducted by Aburas et al. (2015) in Malaysia using NDVI found that vegetation cover was decreased and non-vegetated areas increased during 1990 and 2010. The socio-demographic data analysis showed that massive population resettlement and high rate of population growth exerts pressure on land resources of the area. Population increment needs cultivable land for their livelihood requirements. This situation forced the settlers to encroach into vegetated areas for cropping, grazing and settlement which intensify the conversion of vegetation cover in the area.

The resettlers' livelihood strategies are found to be main driving force for the existing vegetation cover dynamics. The existing expansions of traditional farming practices into grasslands, forests and woodlands eventually led to a decrease in vegetation cover. In addition, households are increasingly engaged in firewood

collection and charcoal production as lucrative livelihood strategies. Particularly, poor households, the landless and jobless youths are highly dependent on charcoal and firewood sale to fulfill the livelihood requirements. In agreement to this finding, Kidane et al. (2012) in the Bale mountain of Southeast Ethiopia found that population growth and resettlement have caused vegetation dynamics due to encroachment of settlers into vegetated areas for farm plots and settlements. The key informants and focus group discussion participants mentioned that the existing land tenure system has also contributed to vegetation covers changes in the area. Respondents feel as they have no full right over the land (land tenure insecurity). Hence, they lack preparation and initiation to take environmental protection actions like afforestation and reforestation programs. They further mentioned that lack of land use planning and environmental impact assessment before the execution of resettlement program has contributed to the depletion of vegetation resources in the area. Besides, the result showed that deforestation and forest fire incidence for agricultural land clearing has resulted in the depletion of vegetation cover in the area. Similarly, Walle et al. (2011) in the resettlement areas of Metema and Quara woredas, Amhara region of Ethiopia pointed out that the problem of forest fire due to charcoal production and agricultural land expansion poses a serious threat on vegetation resources. In general, resettlement scheme coupled with a range of demographic, socioeconomic and institutional related factors underpin the observed changes in Chewaka district.

Implications on vegetation resource conservation

Changes in natural land covers are inevitable phenomenon mainly due to human–environment interactions that involve various implications. These implications could be positive (convey of desirable change to protect and regain vegetation cover) and negative (undesirable changes). In this regard, massive population resettlement coupled with socioeconomic activities of the resettlers' has exacerbated the depletion and dynamics of vegetation cover in Chewaka district. Consequently, resettlement scheme has threatened and posed great damage on vegetation resources of the area. This implies unless appropriate and immediate conservation measures are undertaken, the remaining vegetation resources of the district could disappear within a few years. Thus, the findings from this study have implications for sustainable conservation and utilization of the remaining vegetation resources. First, the dependency of the local people on the remaining vegetation resources should be minimized by promoting the use of alternative energy sources that are environment friendly as well as through livelihood diversification activities. Second, to reduce the potential impacts on

vegetation resources of the area, resettlement program should be closely monitored and regularly re-evaluated by concerned stakeholders. Third, afforestation and reforestation program should be done by the government in collaboration with other concerned bodies. Fourth, mobilizing local community participation by enhancing awareness raising program, strengthening coordination and collaborative works among different stakeholders are important for sustainable vegetation resource management of the area. Furthermore, developing proper land use plan and limiting population growth through family planning are found to be imperative to conserve and protect the remaining vegetation resources of the district.

Conclusion

This study analyzed the impact of resettlement scheme on vegetation cover and its implications on conservation in Chewaka district of Ethiopia. The results showed that Chewaka district has undergone substantial LULC change since population resettlement in the area. There have been dramatic decreases in forests, woodlands, grasslands and barelands, while built-up areas and cultivated lands have increased profoundly during the study period. The results of NDVI analysis indicated that the extent of dense and sparse vegetation cover have decreased by 26.1% and 20.6% respectively, whereas non-vegetation cover has increased by 14,340.2 ha during 2000–2018. It was found that rapid population growth mainly due to resettlement program, farmland and settlement expansion, deforestation, forest fire, lack of proper land use plan, unwise utilization and low management practices were identified as major drivers that underpin the observed changes in the area. This implies population resettlement has exacerbated the depletion and dynamics of vegetation cover in the district. Therefore, the study suggests urgent attention on conservation of the remaining vegetation resources for sustainable utilization by limiting population growth through family planning, promoting livelihood diversification strategies, mobilizing local community participation by enhancing awareness raising program, controlling forest fire, developing proper land use plan, provision of alternative energy, afforestation and reforestation activities. In general, the combined use of GIS and remote sensing techniques as well as socio-economic data could provide useful baseline information to understand the patterns of change and driving forces so as to design effective management options and protect the remaining vegetation resources.

Abbreviations

BZARDO: Buno Bedelle Zone Agriculture and Rural Development Office; CSA: Central Statistical Agency of Ethiopia; DEM: Digital Elevation Model; ERDAS:

Earth resource data analysis system; ETM+: Enhanced Thematic Mapper Plus; FAO: Food and Agricultural Organization; GCPs: Ground control points; GIS: Geographic information system; GPS: Global Positioning System; ha: Hectare; LULC: Land use/cover; NDVI: Normalized Difference Vegetation Index; NMSA: National Meteorological Service Agency; SNNPR: Southern Nations, Nationalities and Peoples Region; TM: Thematic mapper; SPSS: Statistical Package for Social Science; USGS: United States Geological Survey.

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Authors' contributions

AA has lead the overall activities of the research process such as designing the study, data collection, analysis, interpretation and writing the draft manuscript; TY and AU have made significant contribution by providing constructive guidance, critical comments and suggestions in the manuscript preparation process as well as editing the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

An effort was made to conduct the research in an ethical manner. A research site permission letter was obtained from the concerned institutions and the participants' consent was asked before commencing the interviews, discussions and taking photographs.

Consent for publication

All authors agreed and approved the manuscript for publication in Environmental Systems Research.

Competing interests

The authors declare that they have no competing interests.

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