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Effects of Landuse and Land Cover Changes on the Extent and Distribution of Afroalpine Vegetation of Northern Western Ethiopia: The Case of Choke Mountains

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ABSTRACT
The highlands of Ethiopia host the afroalpine and sub-afroalpine vegetation, one of the major vegetation types of Ethiopia. Due to the rugged topography and high population pressure, these regions have experienced sever land degradation. The main objective of this study was to investigate the dynamics in landuse/land cover and its effect on the extent and distribution of afroalpine vegetation. Four periods of Landsat TM for 1986, 1995, 2005 and 2011 were analysed. Vegetation study was conducted using systematic sampling by laying line transects along elevation gradients. Group discussion was made with two representative community groups of the study area. From remote sensing data four landuse/land cover types were identified: Crop land, ericaceous forest, grassland and shrub land. The result showed that the cropland had increased by 206% between 1986 and 2011, whereas ericaceous forest, grasslands and shrublands have decreased by 79, 40 and 17%, respectively in the same period. The vegetation analysis showed that 31 plant species belonging to 19 families were recorded. Out of these species, only four species were from a member of tree layer and 27 species were from herbs, grasses and shrubs categories. *Erica arborea* and *Euryops antinorii* were found the dominant from woody species and herbaceous plants respectively. Results from group discussions reveled that Choke Mountain ranges were historically covered by ericaceous dominating mosaic forest. However, the extent of ericaceous vegetation is now greatly declined due to anthropogenic disturbances. Based on our result we recommend community based resources management scheme in the afroalpine areas of Choke Mountain ranges where the community should be allowed to use sustainable grazing while protecting the woody vegetation. However, crop farming in the afroalpine belts should be strictly prohibited to conserve the entire landscape.

Key words: Afroalpine, conservation,Choke Mountain ranges, landuse, vegetation

INTRODUCTION
The afroalpine region in Africa is found across the scattered high mountains of East African countries mainly in Ethiopia, Kenya, Tanzania and Uganda (Kebede *et al*., 2007). An area with altitudinal elevation higher than 3200 meter above sea level (masl) is generally referred as afroalpine and sub-afroalpine dominated by high shrub and grassland vegetation (Marino, 2003; Hedberg, 1951). The lower limit of the afroalpine vegetation belt falls at about

3500 masl, while the upper limit of vascular plants lies around 5000 m (Hedberg, 1969, 1970) and sub afroalpine areas ranges between 3200-3500 masl. Ethiopia accounts for the largest extent of afroalpine areas with 80% of the land over 3000 masl in Africa (Yalden, 1983). These areas include chains of mountains, slopes and tops of highest mountains, The afroalpine and sub-afroalpine areas are highly fragile due to the extreme climatic conditions and undulating topography (Hedberg, 1970).

In many parts of the world, demand for agricultural land and timber have been aggravating changes on the landscape patterns of different ecosystems (Sivrikaya *et al*., 2007). Thus, investigating landscape structure and its change is a prerequisite to the study of ecosystem functions and processes, sustainable resource management and effective landuse planning (Matsushita *et al*., 2006). Continued effort to develop and maintain spatio-temporal datasets in different regions will aid in the identification of contributing factors in landuse and cover change (Nagendra *et al*., 2004).

Landuse and land cover changes and degradation of natural resources, particularly vegetation and soils, are increasing at alarming rate in the highlands of Ethiopia (Zeleke, 2000; Zeleke and Hurni, 2001). Non-coherent decisions, weak landuse policies and unstable government organization structure have led to the transformation of natural habitats to other landuse (Gelet *et al*., 2010). As a result, most of the faunal and floral resources of afroalpine and sub-afroalpine regions of Ethiopia are under high pressure from intensive human landuse. Farmers often push onto steeper and steeper slopes of these regions for crop farming which can only give yields for a few years before the soil is washed away (Hedberg, 1970). The Erica-Hypericum woodlands are being over utilized and the area coverage by this plant community has declined continuously during the past 30 years and at present. Evidences in the recent past indicated that afroalpine areas occupy only less than 10% of their original area (Gottelli *et al*., 2004). If the heavy utilization of afroalpine resources continues at the same pace for the coming decades, the more easily accessible highlands dominantly covered by Erica-Hypericum woodlands might disappear in foreseeable future (PGRC, 1995).

Despite several studies have made important reports on the vegetation and ecology of afroalpine regions in Ethiopia, these studies are focused on the Bale and Simien Mountains. However, detailed researches for the other afroalpine ranges of the country like Choke Mountain ranges are very scanty (Hedberg, 1970; FZS, 2007; Kebede *et al*., 2007). Except some afroalpine regions such as Bale and Simien, most of the highlands above 3000 masl in Ethiopia are not under government protected area categories. In these areas there are limited conservation measures for the protection of the species loss and sustainable use of the ecosystems. In addition, rapid population growth which resulted in rapid agricultural expansion at the expense of the forest resource and free grazing system aggravates the depletion of the ecosystem including soil erosion and water resource degradation. However, the magnitude of landuse and land cover change and the current status of the Ericaceous vegetation resource are not known.

Hence, Choke afroalpine areas are severely threatened by the agricultural land expansion and livestock overgrazing which would ultimately lead to excessive soil erosion and disrupting hydrological system of the area. Therefore, it is very important to investigate the landuse/land cover and vegetation changes of Choke Mountain ranges. The current study was conducted to investigate the landuse/land cover change and vegetation status of Chokes so as to recommend conservation mechanisms for the sustainable management of this area. The specific objectives of this study were (i) To study the landuse and land cover change and its implication on the vegetation status, (ii) To study the afroalpine plant compositions of the area and (iii) To investigate the attitudes of local community on the management and utilization of afroalpine resources.

METHODS

Study area: This study was conducted in North-Western Ethiopia at Choke Mountain ranges of Amhara National Regional State with particular reference to afroalpine and sub-afroalpine areas (>3200 masl). The area was selected based on the topographic map of the study area taking the contour lines as a base to determine afroalpine and sub-afroalpine limits. The alpine ranges in the North Western Ethiopia comprise most of the highlands of Eastern Gojjam having many peaks with the highest peak reaches 4052 msal and it covers about 52139 ha (Fig. 1). These peaks endowed with magnificent scenery overlooking all the rest of low lying lands in the surrounding areas. The area is known to have inactive volcanic center composed of basalt rock with a very thin cover of pyroclastic materials (Habtamu, 2003).

Choke Mountain ranges are inhabited by nucleated settlement pattern and the land is converted in to field of strips where various cereals are grown on fragmented landscape (Habtamu, 2003). These ranges are the sources of four big rivers namely: Muga, Chemoga, Abeya and Techma and many other small tributaries of the Blue Nile (Abay) River. The area was historically known for dense forest of afroalpine vegetation such as short shrubs and grasslands with mosaic patches of Ericaceous plants which are now highly degraded with overgrazing and crop cultivation (Teferi *et al*., 2010; Simane *et al*., 2013).

Landcover classification and change detection: Four Landsat images of cloud-free for the years 1986, 1995, 2005 and 2011 were used for this study. These images were ortho-rectified and projected to UTM zone 37N, WGS 1984 (Tucker *et al*., 2004). A false color and true color composites

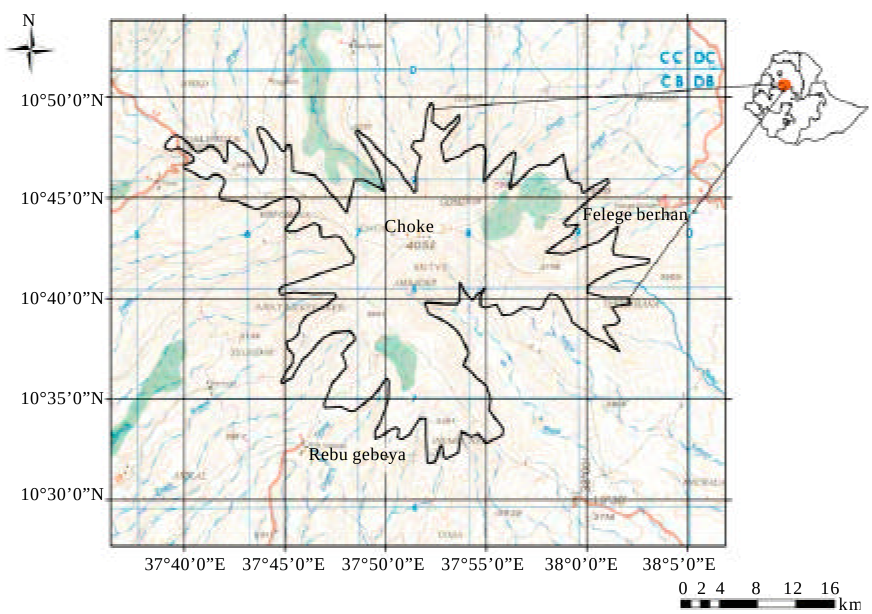

Fig. 1: Map of the study area

were processed to identify the different land cover classes in the study area. Band combinations of these color composites were used to select training signature for supervised classification. From the information extracted, the spectral response for different features and land cover types were analyzed. The color composition of band combinations of the satellite images of the study area were checked for better interpretation to make sure that they are useful for the analysis of landuse types and to prepare the image for classification. In this regard, the combination of the red (band 4), the green (band 3) and the blue (band 2) was found the best for identification of most of the categories of land cover classes. Ground control points were collected from the field and used to verify the landuse/land cover types.

Changes in spatial extent of different land cover types over time were investigated using a supervised landcover classification algorithm (maximum likelihood method) to determine changes in landcover on a decadal basis between 1986 and 2011. For a clear comparison of the land cover dynamics during classification, some land cover types were generalized when the cover classes are represented by fewer numbers of pixels. To alleviate the problems of misclassification of individual pixels, we used majority analysis to remove noise and smoothen the landcover results.

For the comparison of two independently produced classified landuse/cover maps from images of two different dates, post-classification comparison change detection algorithm was performed (Yuan *et al.*, 1998, 2005; Yang, 2002; Teferi *et al.*, 2010). This post-classification approach provides statistical evidence that indicates the rate and magnitude of landcover changes over time (Singh, 1989; Long *et al.*, 2007; Martinez *et al.*, 2009).

Vegetation data collection and analysis: A systematic sampling design was used to collect vegetation data (Mueller-Dombois and Ellenberg, 1974; Kent and Coker, 1992; Krebs, 1989; McCune and Grace, 2002). Seven transects lines representative of the study area were purposely laid down along the elevation gradient and vegetation data were collected from 28 sq quadrates of 20×20 m that were distributed along transects following the elevation gradient at 100 m vertical interval and the interval between the transects was 400 m. Within each 20×20 m quadrates, a 1×1 m sample plot was established to collect data on herbaceous plants. Plant press with its full accessories, Garmin GPS60, Silva Compass, digital camera, topographic map of the study area (1:50,000 scale) and data sheets were used to collect data from the field.

Plant species were identified using plant fieled guide books of Medicinal Plants and Other Useful Plants of Ethiopia (Abebe *et al.*, 2003) and Honey bee flora of Ethiopia (Fichtl and Adi, 1994). For plant species which were difficult to be identified, specimens were collected and pressed at field and identification was made at the National Herbarium at Addis Ababa University.

Since there were very few woody plant species for counting, the species diversity was determined using the species richness (the number of species in the sample plots). The average density of individual woody plant species were calculated based on the number of individuals observed at plot level and then converted to a per-ha basis.

Historical data collection and analysis: Group discussion was conducted on the two user groups purposely selected from the Choke Mountain ranges based on the proximity of the community to the study area. These two user groups were selected from Abazash area in the South West and Shewa Kidane Miheret in the North East which are dominantly utilize the afroalpine resources. In each group 20 individuals were participated and a two hour discussion for each group was conducted by taking notes on the important issues related to the management and utilization of afroalpine resources. The discussion was focusing on the vegetation history of the area, the conservation status, protection system, the land ownership, current situation of the forest, the afroalpine grazing system and the water resource use of the study area. As the discussion was qualitative and more exploratory in nature, data were analyzed following the approach of qualitative data analysis.

RESULTS

Land cover classification and change detection: Four major landcover/landuse classes were defined based on the TM Lands at images and ground truthing. These include: The crop lands, the Ericaceous forest, the afroalpine grasslands and shrublands. The land cover classes, the magnitude and the net changes for the studied periods are presented in Table 1.

The result showed that the cultivated land has increased by 206% between 1986 and 2011. However, the afroalpine vegetation (Ericaceous forest, grasslands and shrublands) have decreased by 79, 40 and 17%, respectively between 1986 and 2011. In these periods, the highest decrease was observed for Ericaceous forest which is reduced by 13% of its original area in the region whereas the crop land is increased by 34% of its original area in the entire afroalpine region of the study area. Comparison to all periods concerning landuse, a rapid change was observed since 1995 which clearly shows a large portion of the alpine vegetation is converted to cultivated land. The spatial distribution of detected changes in land cover (Fig. 2) illustrates a widespread replacement of alpine vegetation by crop lands.

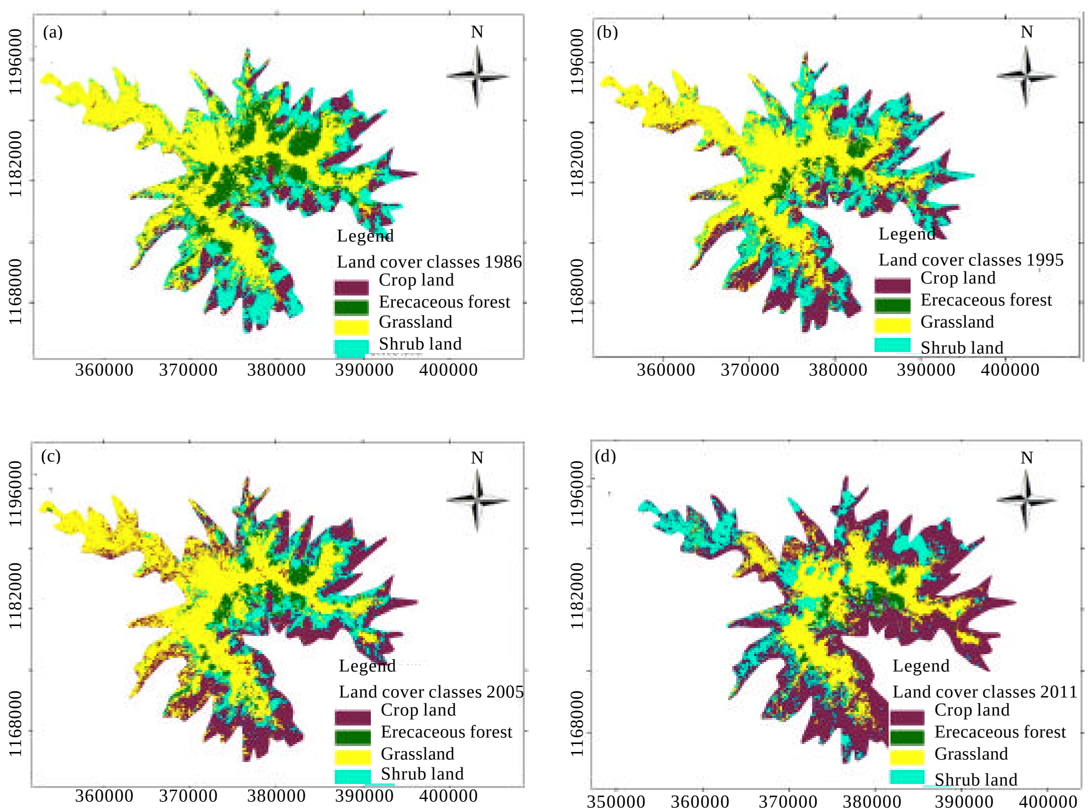

Fig. 2(a-d): Landcover classifications maps of Choke alpine regions of, (a) 1986, (b) 1995, (c) 2005 and (d) 2011

Plant species composition: A total of 31 plant species belonging to 19 families were identified in the study area of which only four species formed tree layer, whereas the majority vegetation are grasses, shrubs and herbaceous plants. At the family level Asteraceae is the dominant family representing 29% of the total plant family in the study area (Table 1 and 2).

Erica arborea is the dominant woody plant species in the study area and the number of individual plants per hectare ranging from 7 in a very disturbed area to 17600 in a dense forest. The second dominant plant species was *Lobelia rhynchopetalum* with the number of individuals ha^{-1} ranging from 5 in a very disturbed area to 6000 individuals ha^{-1} in dense lobelia vegetation (Fig. 3). Scattered *Hagenia abyssinca* and *Hypericum revolutum* with small number of individual trees were also found mixed within the Ericaceous forest.

From herbaceous plants, *Euryops antinorii* was found as the dominant species with wider distribution and the number of individual plant head per hectare was ranging from 16000 stems to 49000 (Fig. 4). This plant was observed and reported by the local community as a useful plant for fuel material for the local community after considerable drying.

Subilaria monticola is one of herbaceous plants commonly found along the stream source that gives the area attractive in terms of scenic value (Fig. 5).

Local historical knowledge and conservation strategy: The results from the group discussions showed that some 30 years ago there were mosaic forests of alpine vegetation with *Erica arborea* and *Hypericum revolutum* being the dominant species in the woody species

Table 1: Land cover classification for 1986, 1995, 2005 and 2011

	1986		1995		2005		2011		Relative change
Land cover class	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	1986-2011 (%)
Crop land	8660	17	13419	26	17770	34	26527	51	206
Ericaceous forest	8513	16	2521	5	1841	4	1807	3	-79
Grassland	22499	43	22685	44	23909	46	13438	26	-40
Shrub land	12466	24	13514	26	8619	17	10367	20	-17
Total area	52139	100	52139	100	52139	100	52139	100	

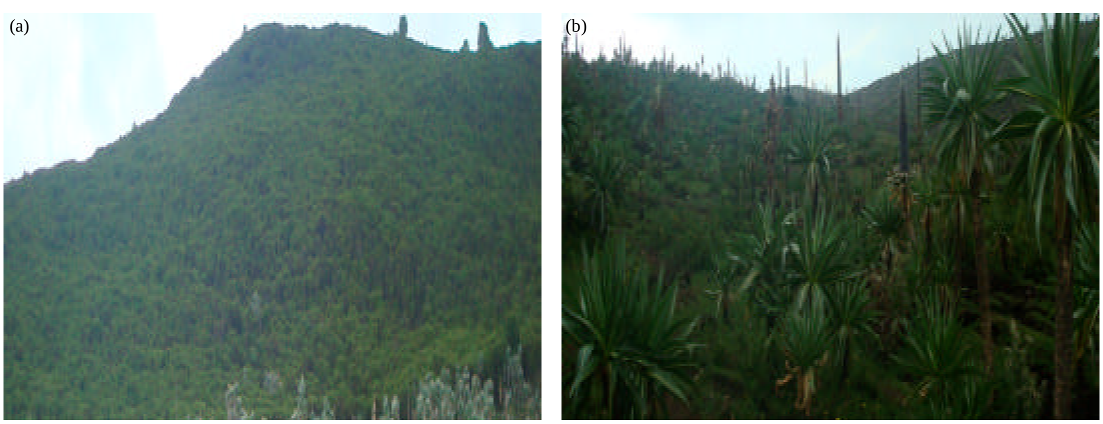

Fig. 3(a-b): Two dominant woody plants in the study area (a) *Erica arborea* and (b) *Lobelia rhynchopetalum*

Table 2: List of plant species recorded in the study area

No.	Species name	Family name	Habit
1	*Cardamine oblique* A. Rich.	Brassicaceae	Herb
2	*Carduus nyassanus* (S. Moore) R.E. Fries	Asteraceae	Shrub
3	Carex petitiana A. Rich.	Cyperaceae	Herb
4	*Cerastium octandrum* A. Rich.	Caryophyllaceae	Herb
5	*Cineraria* sp. Sond.	Asteraceae	Herb
6	*Cyanotis barbata* D. Don	Commelinaceae	Herb
7	*Cyperus elegantulus* Steud.	Cyperaceae	Grass
8	*Echinops* sp.	Asteraceae	Shrub
9	*Epilobium stereophyllum* Fresen.	Onagraceae	Herb
10	*Erica arborea* L.	Ericaceae	Tree
11	*Euryops antinorii* (Avetta) S. Moore	Asteraceae	Herb
12	*Festuca abyssinica* Hochst. ex A. Rich.	Poaceae	Grass
13	*Hagenia Abysinica* (Bruce) Gmelin	Rosaceae	Tree
14	*Haplocarpha rueppelli* (Sch. Bip.) Beauv.	Asteraceae	Herb
15	*Hebenstretia angolensis* Rolfe	Scrophulariaceae	Herb
16	*Helichrysum citrispinum* Del.	Asteraceae	Herb
17	*Helichrysum stenopterum* DC	Asteraceae	Herb
18	*Hypericum revolutum* Vahl	Hypericaceae	Tree
19	*Kniphofia foliosa* Hochst.	Asphodilaceae	Herb
20	*Lobelia rhynchopetalum* Hemsl.	Lobeliaceae	Tree
21	*Pimpinela* sp.	Apiaceae	Herb
22	*Ranunculus stagnalis* Hochst. ex A. Rich	Ranunculaceae	Herb
23	*Rhabdotosperma scrophulariifolia* (Hochst. exA. Rich.) Hartl	Scrophulariaceae	Herb
24	*Satureja simensis* (Benth.) Briq.	Lamiaceae	Herb
25	*Satureja sp.* (Benth.) Briq.	Lamiaceae	Herb
26	Senecio farinaceus Sch Bip. ex A. Rich	Asteraceae	Herb
27	*Senecio steudelii* Sch. Bip. ex A. Rich.	Asteraceae	Herb
28	*Silene burchellii* DC.	Caryophyllaceae	Herb
29	*Subilaria monticola*		Herb
30	*Swertia lugardae* Bullock	Gentaniaceae	Herb
31	*Trifolium* sp.	Papilionaceae	Herb

Fig. 4: *Euryops antinorii* ('Gimiy' by local name), the dominant herbaceous plant in the study area

Fig. 5: *Subilaria monticola* commonly found along stream source

components. The area that was covered by dense stands of the *Hypericum revolutum* is now devoid of vegetation and only stunted grass and scattered shrubs are found mostly on grazing lands. Elders in the discussion reported that there were variations on the rate of the forest destruction across different periods. The highest rate of forest destruction occurred following the down fall of the Derg regime in 1991 when the community has got open access to the afroalpine area to cultivate crops and access to grazing lands. Since then a large portion of the alpine areas are continuously utilized even beyond to its carrying capacity. As a result species presented in previous periods are now vanished from the area.

The community also reported that there are no direct economic (cash) benefits that are generated from the alpine vegetation. But they mentioned that the forest resource is serving as a shade for livestock and human being during drought periods. The grasses, herbs and shrubs are useful for fattening sheep and oxen which can generate income for their livelihood improvement and survival.

Even though the ranges are providing almost all year round grazing land there is feed shortage in some season of the year. In order to solve this problem the local people are using alternative feed sources like straw. Since the grass is very short in size it is inconvenient for harvesting and making hay.

Very few patches of *Erica arborea* are traditionally conserved by the local community. This tradition of conserving alpine resources started in 1987 where one known monk called ‘Aba Jime’ who had long experience in forest protection has convinced the community to develop positive attitudes towards nature conservation. The continuous patch of ericaceous forest is then termed as ‘Aba Jime forest’, named with the name of the monk. The monk has protected the forest for about 10 years and then after, the community has followed his positive looking to protect the forest.

The priests are also contributing their inputs on the protection of the Ericaceous forest. On Sunday church programs they condemn the cutting of this species. The local people then understand that there will not be good opportunities/happenings/if the forest is cut and they believe that “Bereket Yikensal” Amharic term literally meaning the amount of goods and opportunities will be lost and even the crops will not serve for long as well as it will decrease in amount whenever they are used.

Although, the tradition of forest conservation is put in place, there are some people who illegally destruct the alpine vegetation through grazing and crop cultivation where a large portion of alpine region is converted into crop land.

DISCUSSION

Landuse/land cover change: The result showed that crop land has continuously increased in area extent as compared to other landuse/land cover types between 1986 and 2011. This is attributed to expansion of cultivated land in the Choke Mountain ranges at the expense of alpine vegetation in the region. As a result, the Ericaceous forest once was abundant in the area is now greatly declined and only scattered remnants of fragmented patches remained in the ranges. The reduction of Ericaceous forest by 79%, decrease of grassland by 40% and shrub land by 17% between 1986 and 2011 is an evidence for the increment of crop lands. The devastation of Ericaceous forest was dramatic between 1986 and 1995 as reported in Table 1 from 16 to 5% as compared to recent periods. The reason might be the government change in 1991 which resulted in mass destruction of Ericaceous forest by the local community for various purposes including agricultural land expansion, fuelwood and construction wood collection.

Likewise, similar study reported that the Ericaceous forest is declining in other afroalpine regions of the country. For instance, in Bale s the closed *Erica* forest shrank from 15 to 12.37%, isolated *Erica* shrubs have decreased from 6.86 to 5.55%, afroalpine dwarf shrubs and herbaceous formations reduced from 5.2 to 0.56% between 1973 and 2008 (Kidane *et al*., 2012). The net of change at Choke Mountains is by far greater than that of Bale Mountains. The free grazing system and the continuous expansion of agricultural land expansion might account for the higher rate of land cover change at Chokes as compared to Beles which are officially designated as a protected area and conservation measures are put in place for long period of time.

The information from the group discussion revealed that the driving forces for the landuse change at Choke Mountains are the complex interactions among the bio-physical, socio-economic and cultural processes operating in the region over time. This is in line with other studies where some of the driving forces for landuse change attributed to social and economic factors (Milchunas and Lauenroth, 1993; Fuhlendorf *et al*., 2001). Both human and livestock population pressure are parts of the major driving forces for the shrinking of the afroalpine areas of Ethiopia.

For instance, Vial *et al*. (2011) reported that the Bale Mountains have been under increasing pressure from a rapidly growing pastoralist population and their livestock. In the study area, the increasing human and livestock population resulted in the demand for additional land through the conversion of the existing vegetation resources mainly the Ericaceous forest, grasslands and shrub lands. Several studies showed that livestock grazing is a powerful driver of land cover dynamics and influences the abundance and distribution of the animal and plant communities inhabiting the afroalpine areas (Kruess and Tscharntke, 2002; Schmidt *et al*., 2005; Coppedge *et al*., 2008).

Vegetation status: According to the analysis from Landsat images, the field observation and the evidence from the group discussion, the vegetation status of Choke Mountain ranges has been rapidly decreasing between 1986 and 2011 due to high pressure from human and livestock in all direction of the alpine regions. The mosaic Ericaceous vegetation observed in 1986 is now very fragmented and declined to small patches. The number of plant species recorded in the study area (31) is lower as compared to other afroalpine regions. For instance, Getahun (2009) has recorded 51 plant species from Bale Mountains which is by far higher than Choke Mountains. However, the dominant plant species both in Choke and Bale afroalpine regions are herbaceous plants.

In the study area only one small patch of Ericaceous forest called 'Aba Jime' near to 'Abazash Kebele' (where Kebele is a small administrative unit in Ethiopia) due get protection from the local people commitment. As the information from the local community, the forest has got protection because of its spiritual value and has got its name from a monk called 'Aba Jime' where he had lived for a long time in the same forest.

The local community reported that some 30 years ago during the imperial regime, the Ericaceous forest had had a wider dimension and made mosaic vegetation in the whole ranges of Chokes. The remnants of fragmented patches of Ericaceous forest are evidences for the previous mosaic forests. Even today, the Ericaceous vegetation dominated the woody plant communities of the area. It is the nature of the afroalpine vegetation comprising predominantly the Ericaceae family (*Erica arborea* and *Erica trimera*) (Getahun, 2009), of which only the former species characterizes the study site.

The community also informed the implication of vegetation degradation on the associated resources such as on the decline of water quality and quantity and currently noticed sever soil erosion in the study area. From their field experiences they also noticed that the infiltration capacity of the soil is very poor and the people living in the downstream are suffering from gully erosion and flooding.

Management implications: The decreasing rates and magnitude of change in alpine vegetation at Choke Mountain ranges is attributed to anthropogenic disturbances through crop cultivation and over grazing. Therefore, reduction in Ericaceous forest, grasslands and shrub lands is explained by increase in crop lands between 1986 and 2011.

This area is the source of Blue Nile River and needs to be protected for continuous and clean water supply. Some of the activities to be implemented sooner or later should include, rehabilitating the area with afforestation of native species, soil erosion control and application of low enforcement. Concerning afforestation activities, *Erica arborea* and *Hagenia abyssinca* have similar ecological range where they can grow in the similar elevation and environmental variables. As growing *Erica arborea*, is time consuming, it is advisable to mobilize planting *Hagenia abyssinca* plants in the deforested Ericaceous forest areas of Choke Mountains. Soil conservation measures should be strongly practiced to increase productivity *in situ* and to reduce the amount of sediment load in order not to affect the newly established Grand renaissance dam of Ethiopia.

The local community has experience of rotational grazing and it is important to give backup by development agents so that the local people will be actively involving in the management and sustainable use of alpine resources of Choke Mountain ranges. In this management system, the parcel of the grazing land will have 2-3 months rest period so that forage will develop. The forage development is not only providing forage for livestock but also reduces soil erosion, as the grasses are very dense and growing very close to the ground which is the best characteristics of vegetative soil and water conservation.

Therefore, community based resources management scheme in the afroalpine areas of Choke Mountain ranges should be put in place where the community should be allowed to use sustainable grazing while protecting the woody vegetation particularly the Ericaceous vegetation. However, crop farming in the afroalpine belts should be strictly prohibited to conserve the entire landscape.

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REFERENCES

Abebe, D., A. Debella and K. Urga, 2003. Illustrated Checklist, Medicinal Plants and other Useful Plants of Ethiopia. Ethiopian Health and Nutrition Research Institute, Ethiopia, ISBN: 9781904722007, Pages: 312.

Coppedge, B.R., S.D. Fuhlendorf, W.C. Harrell and D.M. Engle, 2008. Avian community response to vegetation and structural features in grasslands managed with fire and grazing. Biol. Conserv., 141: 1196-1203.

FZS, 2007. Bales national park, general management plan, 2007-2017. Ethiopia.

Fichtl, R. and A. Adi, 1994. Honeybee Flora of Ethiopia. Margraf Verlag, Weikerskein.

Fuhlendorf, S.D., D.D. Briske and F.E. Smeins, 2001. Herbaceous vegetation change in variable rangeland environments: The relative contribution of grazing and climatic variability. Applied Vegetat. Sci., 4: 177-188.

Gelet, M., K.V. Suryabhagavan and M. Balakrishnan, 2010. Land-use and landscape pattern changes in holeta-berga watershed, Ethiopia. Int. J. Ecol. Environ. Sci., 36: 117-132.

Getahun, M., 2009. Post fire influence on erica shrub land within the afroalpine vegetation. A case study in south of the bales national park. M.Sc. Thesis, Southeast Ethiopia.

Gottelli, D., J. Marino, C. Sillero-Zubiri and S.M. Funk, 2004. The effects of the last glacial age on speciation and population genetic structure of the endangered Ethiopian wolf (*Canis simensis*). J. Mol. Ecol., 13: 2275-2286.

Habtamu, M., 2003. Lord, zega and peasant in eastern gojam, C.1767-1901. MA. Thesis, Addis Ababa University School of Graduate Studies.

Hedberg, O., 1951. Vegetation belts of the east Africans. Svensk Botanisk Tidskrift, 45: 140-202.

Hedberg, O., 1969. Evolution and speciation in a tropical high flora. Biol. J. Linnaean Soc., 1: 135-148.

Hedberg, O., 1970. Evolution of the Afroalpine flora. Biotropica, 2: 16-23.

Kebede, M., D. Ehrich, P. Taberlet, S. Nemomissa and C. Brochmann, 2007. Phylogeography and conservation genetics of a giant lobelia (*Lobelia giberroa*) in ethiopian and tropical east Africans. J. Mol. Ecol., 16: 1233-1243.

Kent, M. and P. Coker, 1992. Vegetation Description and Analysis: A Practical Approach. John Wiley and Sons, Chichester.

Kidane, Y., R. Stahlmann and C. Beierkuhnlein, 2012. Vegetation dynamics and land use and land cover change in the bales, Ethiopia. Environ. Monitor. Assess., 184: 7473-7489.

Krebs, C.J., 1989. Ecological Methodology. 1st Edn., Harper and Row, New York, USA., ISBN-10: 0060437847.

Kruess, A. and T. Tscharntke, 2002. Grazing intensity and the diversity of grasshoppers, butterflies and trap-nesting bees and wasps. Conserv. Biol., 16: 1570-1580.

Long, H., G. Tang, X. Li and G.K. Heilig, 2007. Socio-economic driving forces of land-use change in Kunshan, the Yangtze River Delta economic area of China. J. Environ. Manage., 83: 351-364.

Marino, J., 2003. Spatial ecology of the Ethiopian wolf, *Canis simensis*. Ph.D. Thesis, Linacre College, University of Oxford.

Martinez, M.L., O. Perez-Maqueo, G. Vazquez, G. Castillo-Campos and J. Garcia-Franco *et al*., 2009. Effects of land use change on biodiversity and ecosystem services in tropical montane cloud forests of Mexico. For. Ecol. Manage., 258: 1856-1863.

Matsushita, B., M. Xu and T. Fukushima, 2006. Characterizing the changes in landscape structure in the lake Kasumigaura Basin, Japan using a high-quality GIS dataset. Landscape Urban Plann., 78: 241-250.

McCune, B. and J.B. Grace, 2002. Analysis of Ecological Communities. MjM Software Design, USA.

Milchunas, D.G. and W.K. Lauenroth, 1993. Quantitative effects of grazing on vegetation and soils over a global range of environments. Ecol. Monographs, 63: 327-366.

Mueller-Dombois, D. and H. Ellenberg, 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons Inc., New York, Pages: 574.

Nagendra, H., D.K. Munroe and J. Southworth, 2004. From pattern to process: Landscape fragmentation and the analysis of land use/land cover change. Agric. Ecosyst. Environ., 101: 111-115.

PGRC, 1995. Ethiopia: Country report to the FAO international technical conference on plant genetic resources. Addis Ababa, Ethiopia. http://www.fao.org/fileadmin/templates/agphome/documents/PGR/SoW1/africa/ETHIOPIA.pdf

Schmidt, N.M., H. Olsen, M. Bildsoe, V. Sluydts and H. Leirs, 2005. Effects of grazing intensity on small mammal population ecology in wet meadows. Basic Applied Ecol., 6: 57-66.

Simane, B., B.F. Zaitchik and M. Ozdogan, 2013. Agroecosystem analysis of the Choke watersheds, Ethiopia. Sustainability, 5: 592-616.

Singh, A., 1989. Review article digital change detection techniques using remotely-sensed data. Int. J. Remote Sens., 10: 989-1003.

Sivrikaya, F., G. Cakir, A.T. Kadiogullari, S. Keles, E.Z. Baskent and S. Terzioglu, 2007. Evaluating land use/land cover changes and fragmentation in the Camili forest planning unit of Northeastern Turkey from 1972 to 2005. J. Applied Sci., 9: 1260-1270.

Teferi, E., S. Uhlenbrook, W. Bewket, J. Wenninger and B. Simane, 2010. The use of remote sensing to quantify wetland loss in the Choke range, upper Blue Nile basin, Ethiopia. Hydrol. Earth Syst. Sci., 14: 2415-2428.

Tucker, C.J., D.M. Grant and J.D. Dykstra, 2004. NASA's global Orthorectified Landsat data set. Photogrammetric Eng. Remote Sen. 70: 313-322.

Vial, F., D.W. Macdonald and D.T. Haydon, 2011. Response of endemic afroalpine rodents to the removal of livestock grazing pressure. Curr. Zool., 57: 741-750.

Yalden, D.W., 1983. The extent of high ground in Ethiopia as compared to the rest of Africa. SINET Ethiop. J. Sci., 6: 35-39.

Yang, X., 2002. Satellite monitoring of urban spatial growth in the Atlanta metropolitan area. Photogrammet. Eng. Remote Sens., 68: 725-734.

Yuan, D., C.D. Elvidgeand and R.S. Lunetta, 1998. Survey of Multispectral Methods for Land Cover Change Analysis. In: Remote Sensing Change Detection: Environmental Monitoring Methods and Applications, Lunetta, R.S. and C.D. Elvidge (Eds.). Ann Arbor Press, Chelsea, MI., pp: 21-39.

Yuan, F., K.E. Sawaya, B.C. Loeffelholz and M.E. Bauer, 2005. Land cover classification and change analysis of the Twin Cities (Minnesota) Metropolitan Area by multitemporal Landsat remote sensing. Remote Sens. Environ., 98: 317-328.

Zeleke, G., 2000. Landscape Dynamics and Soil Erosion Process Modeling in the Northwestern Ethiopian Highlands. African Studies Series A16. Geographica Bernensia, Berne.

Zeleke, G. and H. Hurni, 2001. Implications of land use and land cover dynamics for resource degradation in the Northwestern Ethiopian highlands. Res. Dev., 21: 184-191.