British Journal of Applied Science & Technology
6(2): 123-137, 2015, Article no.BJAST.2015.073
ISSN: 2231-0843

SCIENCEDOMAIN *international*
www.sciencedomain.org

Agriculture Practice and Its Impact on Forest Cover and Individual Trees in the Mount Cameroon Region

B. A. Fonge[1*], E. E. Bechem[1] and V. N. Juru[1]

[1]Department of Botany and Plant Physiology, University of Buea, P.O.Box 63, Buea, Cameroon.

Authors' contributions

This work was carried out in collaboration between all authors. Authors BAF and EEB designed the study, performed the statistical analysis, wrote the protocol, while author VNJ wrote the first draft of the manuscript and all the authors managed the literature searches. Authors BAF, EEB and VNJ managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2015/12906
Editor(s):
(1) Ahmed Fawzy Yousef, Geology Department, Desert Research Center, Egypt.
(2) Harry E. Ruda, Stan Meek Chair Professor in Nanotechnology, University of Toronto, Director, Centre for Advanced Nanotechnology, University of Toronto, Canada.
Reviewers:
(1) Anonymous, Kathmandu Forestry College, Nepal.
(2) Anonymous, University of São Paulo, Brazil.
(3) Anonymous, University Of British Columbia, Canada.
(4) Anonymous, University Of Western Greece, Greece.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=765&id=5&aid=7221

Original Research Article

Received 23rd July 2014
Accepted 7th November 2014
Published 15th December 2014

ABSTRACT

Land use changes are driven by agricultural intensification. The aim of the study was to evaluate the impact of agriculture practice on forest cover and tree damage. For this, the Mount Cameroon Region was selected as the research site. Semi-structured questionnaires, interviews and focused group discussions were carried out to collect socio-economic data. In addition, field surveys and remote sensing techniques were used. Thus, ten 50 × 50 m sample plots were established in newly opened farms in the study sites. All trees damaged by fire during farming were sampled and the diameter at breast height (dbh ≥ 10 cm) recorded. Ground truthing was done to obtain ground reference data. During this survey, geographical positioning system (GPS) points were recorded from different land uses observed (farmlands, forests, bare ground, plantations and settlement areas) using Garmin eTrex Venture HC GPS. Landsat Thematic (TM) and Enhanced Thematic (ETM+) images were extracted for the years 1986, 2000 and 2008. The results showed that the number of farms cultivated per household correlated positively with the family sizes of the

**Corresponding author: E-mail: ambofonge@yahoo.com;*

respondents (r= 0.98). The annual deforestation rate was 1.09% from 1986-2000, and 0.58% from 2001-2008. Noticeably, agricultural fields were increased by 12 ha annually from 1986-2000, while they were decreased by 33.5 ha from 2001-2008. A total of 460 trees belonging to 98 species of 33 families were damaged. The average basal area of the trees was 1.3 m^2. The highest damage was noticed in Malvaceae. The most important species damaged were *Terminalia superba, Xylopia africana* and *Entandrophragma cylindricum*. Massive tree destruction was recorded due to land use changes specifically agricultural expansions, illegal logging and fuel wood collection with consequent threats to forest biodiversity.

Keywords: Land use changes; agricultural intensifications; forest cover; tree damage.

1. INTRODUCTION

Global record of land use changes to non-forest from forest is 4,967 M ha, which was projected to increase by 6% and 12% by 2015 and 2030 respectively at the expense of natural forests [1]. The annual deforestation rate of 0.5% contributed about 1.14 M ha forest cover loss in Central African Region. Similar findings were noted in Cameroon too, with an annual agricultural expansion of 0.02 ha in the Mount Cameroon Region (MCR) [2,3]. Increased population and their demand for food are driving cause of conversion of agricultural land from forest areas in tropical forest [4]. This land use change is one of the most crucial human impacts on natural ecosystems and their services [5,6].

The Mount Cameroon Region (MCR) which has rich and fertile volcanic soils [7] is close to the coast, and has agro-industrial ventures such as the Cameroon Development Corporation (CDC), Cameroon Tea Estate, (CTE) and small scheme holders. According to the CDC about 43,000 ha land was planted mainly with palm, rubber, and banana [8]. Peasants practice agriculture in small farms of less than 1 ha which are examples of mixed cropping of cocoyam, maize, plantains, yams, cassava, and vegetables. According to FAO [9], a change in the use of land was one of the established global changes that caused forest degradation worldwide. Bird species were affected by agricultural intensifications [10], due to decline in invertebrates and seed food [11]. Forest degradation is a cause of biodiversity loss and habitat destruction. Other important consequence was drop in finance of forest dependent communities [12]. Loss of biodiversity affects ecosystem function, stability and productivity at different levels [13]. McKee et al. [14] reported that anthropogenic impacts accounted for 87.9% species threat across the moist humid tropical rain forest. According to [15] such impacts caused species extinction when habitats are destroyed. Habitat destruction increases the vulnerability of forests to natural disasters such as floods, drought, crop failure, spread of diseases, and water contamination, together with alterations in the nitrogen, phosphorus, sulphur, and carbon cycles [16]. A decline in any single species is very relevant to biodiversity conservation and resource management [17]. Therefore this study addresses the following research questions; (i) what are the different land uses and farming practices in the MCR? (ii) What are the effects of land use and agriculture on forest cover? (iii) How do farming practices affect individual trees and forest biodiversity in the MCR? In order to answer these questions the research seeks to:

i. Show the existing land use and agriculture practice.
ii. Evaluate the trend of forest cover loss.
iii. Evaluate the damage analysis of individual trees.

2. MATERIALS AND METHODS

2.1 Study Site

The MCR is found in the South West Region of Cameroon and covers a surface area of 5,695.5 km^2 (3), stretching from latitude 3°57' to 4°28' N and longitude 8°58'to 92°4' E [18]. The altitude ranges from just about 20 m above sea level to 4,100 m, called Mount Cameroon situated at 4°13' N and 9°10' E. This is the highest point in West and Central Africa. The climate is humid with annual rainfall ranging from 2085 mm to 10,000 mm. The mean annual temperature is 25°C and this decreases by 0.6°C per 100 m ascent [19]. According to Institute of National Statistics Cameroon, in the year 2010 there were 1,384,300 people in the South West Region of Cameroon. Of this, about 400,000 people live around the Mount Cameroon National Park area [20], with an average of 7.9 people per house hold [21].

The landscape comprises tropical beaches, swamps, tropical and montane forests, together with agricultural lands. Cable and Cheek [22] described this region as one of the most biologically diverse sites in Africa, with about 2,500 indigenous and naturalized plant species, with 42 of them endemic to this region. The present study was carried out in five sites; Bokwango, Bova, Bonakanda, Bimbia (Bonangombe and Bonabile), and Idenau (Sanje village, Scipio and Rechts Fluss CDC camp). These areas were selected to include the leeward and windward sides of the mountain, and to cut across montane and coastal settlements in the Mount Cameroon Region at different elevations (Fig. 1).

2.2 Methods

Socioeconomic-, Landsat images and biophysical data were collected.

The socioeconomic data were collected through interviews with key respondents, pre-set questionnaire and focused group discussions [23]. This data was collected following informed consent of the respondents.

Landsat images: Remotely sensed Images TM, ETM of the years 1986, 2000 and 2008 were downloaded from the Global Land Cover Facility (GLCF) at 30 m resolution (Plate 1). The images were georeferenced and geocoded. These were then classified using supervised maximum likelihood parametric classifier in ArcGIS image analysis software version 9.3 [24]. The GPS coordinates were collected from four land use categories; forest, settlement, water and bare ground.

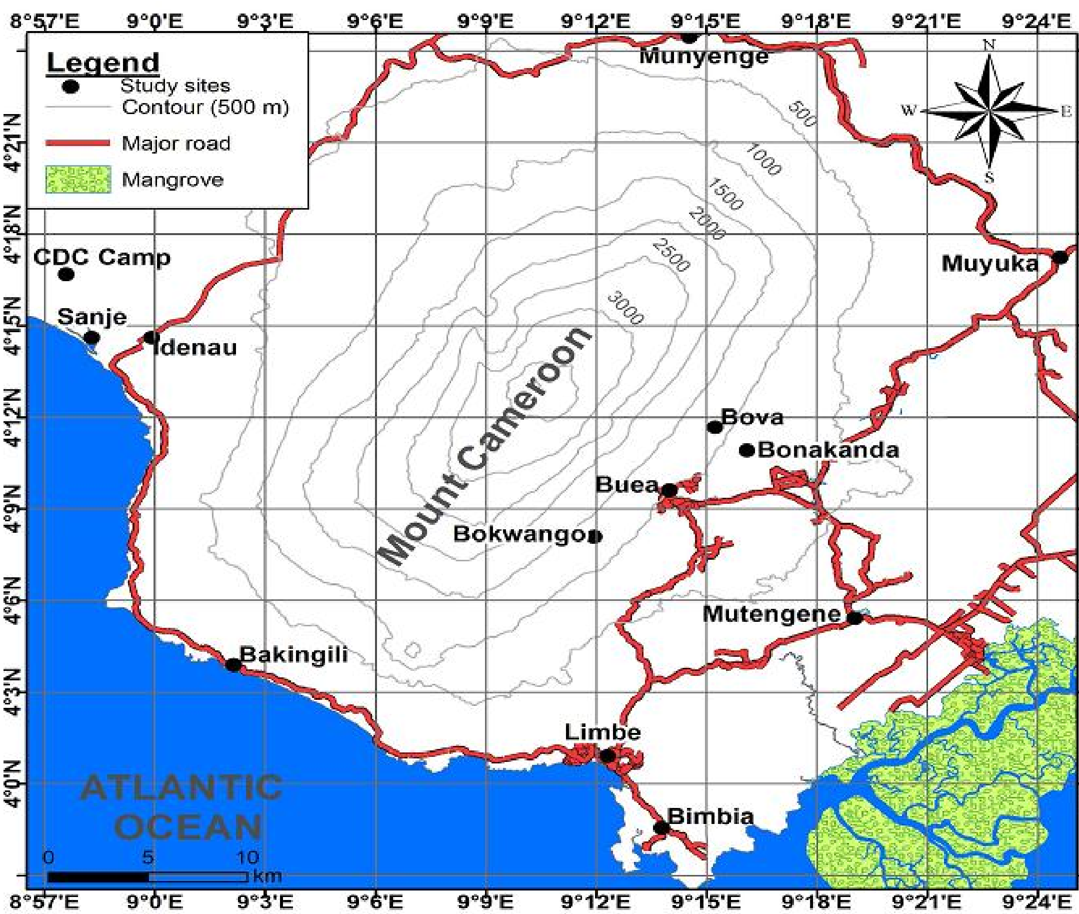


Fig. 1. Map of the mount Cameroon region showing the study villages

Biophysical data: This was focused on damage of individual trees and data obtained through farm surveys. Ten plots of 50 × 50 m (0.25 ha) were established within randomly selected newly opened farms and sampled. Five of these farms were in the montane forest area and 5 in the coastal forest. In each sampling plot, all tree species present were counted and identified using structural and morphological characteristics. Voucher specimens of unidentified samples were taken to the Limbe Botanic Garden for identification and confirmation. The dbh for each individual tree under damage (lower portion debarked and burnt) was measured at 1.3 m from ground level. Stumps left from timber logging were counted. The dbh of the trees were used to compute the basal area (BA) and relative basal area (RBA). The relative density (RD) of each tree species was calculated and the total density of all tree species encountered recorded. The frequency (F) of each species was calculated in the different plots studied. This was used to compute the relative frequency (RF). The Importance Value Index (IVI) of each species destroyed was gotten using the formula of [25]. The cover value index (CVI) was calculated for each plot using the methods of [26] and [27] (Appendix A1 to A7).

2.3 Data analysis

Socio-economic data were analysed using descriptive statistics in the Statistical Package for the Social Sciences (SPSS) version 13.0.

Image data analysis: Colour composites of bands 7-4-2 were used to display images in standard colour composites for land use and vegetation mapping [28]. The maps were compared on pixel by pixel basis. Change detection of the various land cover categories was done by comparing land cover statistics [29]. Annual rates of change of land cover types were gotten by dividing the total change in cover type (in ha) within each period by the number of years between the periods.

Bio-physical data analysis: Microsoft Excel 2010 package was used to compute the basal area, relative frequencies and densities, cover value and importance value indices. Data on number of trees damaged and basal area were analyzed using statistics.

3. RESULTS

3.1 Existing Land Use and Agriculture Practice

Land is used in the MCR for farming, house construction, plantations, fallow plots, tourists' site and forest reserves. The most common land use identified by most respondents (35.4%) was farm lands (Table 1). Results from focused group discussion and interview of the elderly showed that fallow periods which was 5 to 7 years was dropped to 0 to 2 years, and that larger farms were now opened and cultivated the forest.

About 84.0% of the respondents showed that subsistence farming was the most common agricultural system practiced while nearly 16.0% of them practiced plantation agriculture (large estate or farm where crops such as coffee, cocoa, palm, banana, rubber trees etc. are grown).

About 52.2% of respondents owned 5-8 different farm lands while 8 of them (7.1%) had 13-16 farms. Twenty three (20.4%) of them owned 1-4 and 9-12 farm lands respectively. Fifty four respondents (46.0%) had farms of average size 0.27 has (ha), while 2 of them (1.8%) had farms which were bigger than a hectare. A cross tabulation between farm sizes and number of farms showed that 41(69.5%) of the 59 respondents who owned 5-8 farms had these farms of average size 0.27 ha.

It was observed that households with few individuals had less number of farms, with a strong positive correlation between the number of farms and family sizes (r= 0.98) (Table 2).

Table 1. Relationship between the size of the family (individuals per household) and the number of farms owned by respondents in the study villages of the MCR

Family size	Number of farms owned				Total
	1-4	5-8	9-12	13-16	
1-5 persons	21	3	0	0	24
6-10 persons	1	54	0	0	55
Above 10 Persons	1	2	23	8	34
Total	**23**	**59**	**23**	**8**	**113**

Table 2. Surface cover areas of different land uses of the MCR for the year 1986, 2000 and 2008, with cover changes and percentage change from 1986-2000 (14 yrs.), 2000-2008 (8 yrs.) and 1986-2008 (22 yrs.)

Cover type	Land cover for different years			Changes in surface cover, annual changes and % change								
	1986	2000	2008	1986 - 2000			2000 - 2008			1986 - 2008		
				Total change (Ha)	Annual change (Ha/yr)	%	Total Change (Ha)	Annual change (Ha/yr)	%	Total change (Ha)	Annual change (Ha/yr)	%
Dense forest	1993	1688	1610	-305	-21.79	-1.09	-78	-9.75	-0.6	383	-17.41	-0.87
Agricultural fields	1174	1342	1074	+168	+12	+1.02	-268	-33.5	-2.5	-100	+4.55	+0.39
Settlements/bare ground	45	92	150	+47	+3.36	+7.46	+58	+7025	+7.9	+105	+4.77	+10.6

3.2 Trends of Forest Cover Change

The results from the ground truthing data showed that out of the 49 GPS points recorded, 38 points representing about 77.5% exactly fitted with the land use of the classified map of 2008. In 1986 there was 1,993 ha dense forest which decreased to 1,610 ha in 2008 with a forest cover loss of 385 ha. The dense forest cover loss recorded was 305 ha from 1986 - 2000 and 78 ha from 2000 to 2008 (Plate 2) while agricultural fields increased by 168 ha from 1986 to 2000, and decreased by 14.3 ha from 2000 to 2008 (Table 2).

Settlement areas increased by 47 ha between 1986 and 2000 and further increased by 58 ha between 2000 and 2008. Agricultural fields had an annual increase rate of 12 ha from 1986 to 2000 (1.02%). From the year 2000 to 2008, agricultural fields had an annual decrease of 33.5 ha (2.5%). From 1986 to 2008, agricultural fields decreased at an annual rate of 4.55 ha (0.39%).

From the map 5 classifications were identified based on the inability to clearly separate green vegetation from forest with that of savannah and other vegetation types as a result of the cloud cover. The resolution used for the classification was 30 m. The five classification types include forest, plantation, mangrove, settlement, and lava (Table 3).

3.3 Record of Tree Damage

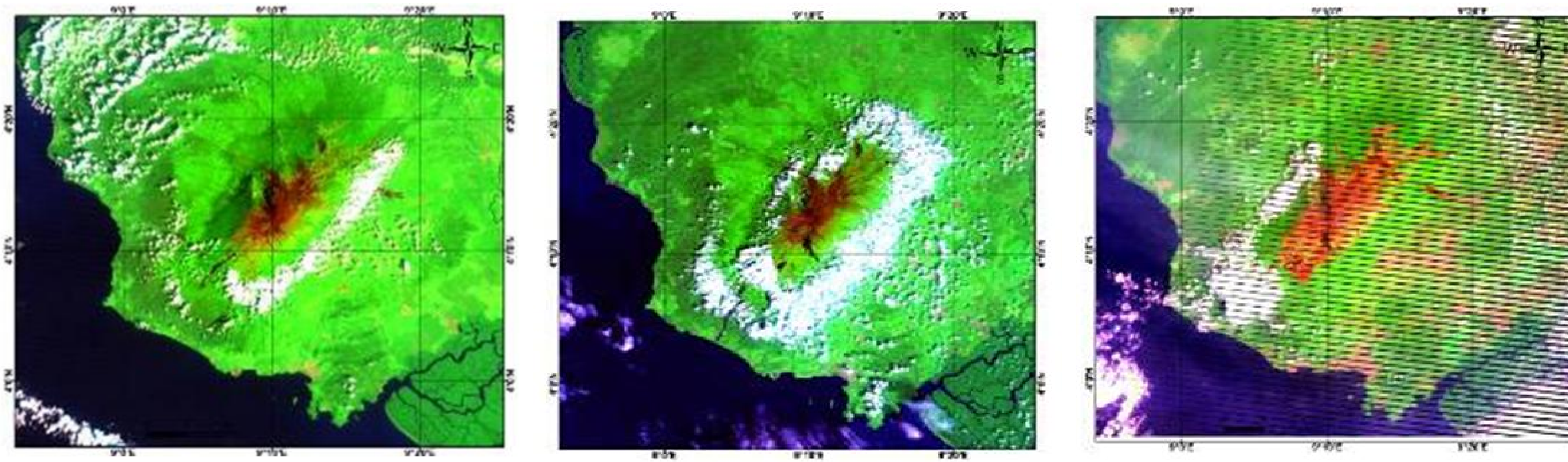
Results from farm surveys showed that there was massive tree destruction during the establishment of new farms. There were 49 unidentified tree stumps in 2.5 ha of newly opened farm land which showed about 19.6 trees/ha. The opening of some farms inside the forest was because of collection of abandoned tree branches after logging (Plate 3e). During this process, the under storey of the forest was removed (Plate 3a) followed by pruning (3b) and debarking of the bottom 1 m of all trees found in the farm area. Fire was set under the debarked portions of trees (3c), and they were finally cut and carried away as fuel wood when dried (Plate 3).

Fuel wood was the only source of energy. About 80-90% of the households used fuel wood for cooking, domestic warming, smoking fish, commercial roasting, and charcoal production. Lophira alata and Rhizophora mangle were the most used species for charcoal production and fish smoking. In the mountain villages, the most preferred species for fuel wood were 'Bwangu' (Grindelia micrantha), 'Sapelle' (*E. cylindricum*) 'Iroko' (*Chlorophora excelsa*), 'ewowo' (*Macaranga occidentalis*) and 'mosenge' (*Macaranga monandra*). These species were abundant in the area before the 1980s to the extent that a quarter in Bonakanda was named 'Wobwangu' meaning 'people of bwangu'. From our observations this tree species was rare in this quarter.

Table 3. Accuracy classification matrices for the classified 1986, 2000 and 2008 Landsat images

Classes (All)	1986		2000		2008	
	Prod. acc. (%)	User acc. (%)	Prod. acc. (%)	User acc (%)	Prod. acc. (%)	User acc (%)
Cloud	81.50	100.00	93.42	100.00	99.04	97.83
Forest	94.17	99.55	95.57	95.72	76.34	87.06
Plantation	96.91	62.92	67.90	67.24	65.00	75.00
Mangrove	85.71	99.86	92.11	95.36	88.12	49.56
Settlement	100.00	99.37	100.00	91.75	99.52	93.36
Lava	99.07	82.17	99.86	100.00	100.00	100.00
Volcano	95.50	100.00	100.00	100.00	99.96	100.00
Water	99.98	100.00	99.91	100.00	99.29	100.00
Overall acc.	**98.26**		**98.49**		**95.55**	
Kappa Coeff.	**0.96**		**0.96**		**0.91**	

NB: Prod. Acc. = producer's accuracy



1 (a) 1986 **1 (b) 2000** **1 (c) 2008**

Plate 1. Extracted images of land landsat scenes of the mount Cameroon region

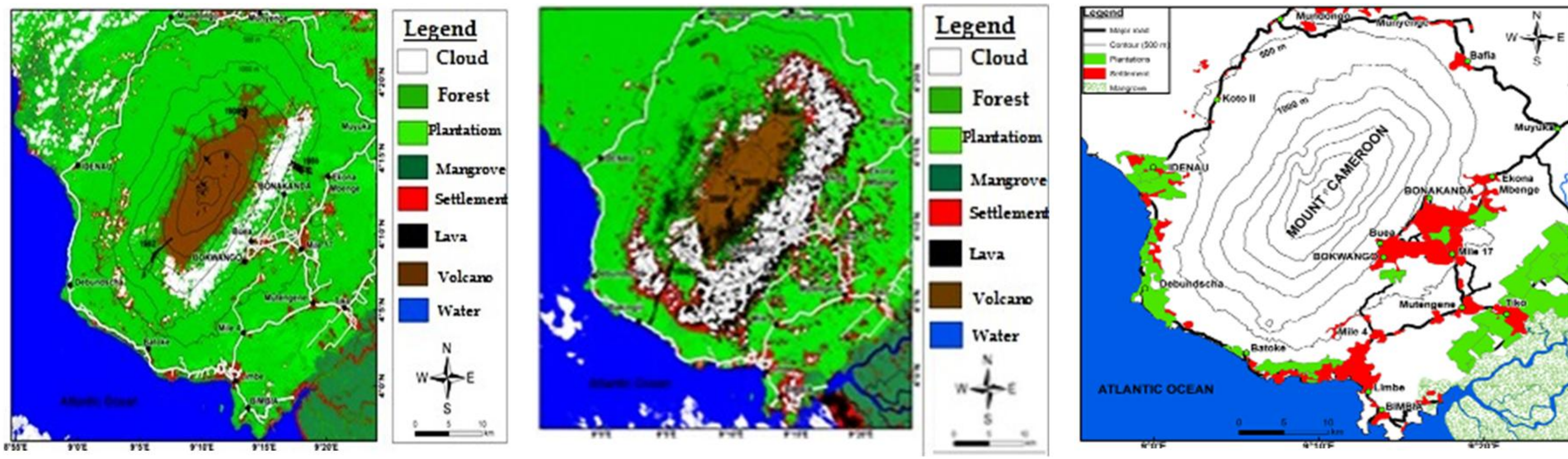


Plate 2a. 1986 classified map

Plate 2b. 2000 classified map

Plate 2c. 2008 classified map

Plate 2. Classified maps of landsat scenes of the MCR for (a) 1986, (b) 2000 and (c) 2008

(a) Removal of the under storey

(b) Pruning, tilling and first planting

(c) Bottom 1m tree debarked and burnt

(d) Tree species, cut for timber

(e) Abandoned wood that attracts the

(f) Established cocoyam farm, all trees cut

Plate 3. Stages of farm preparation showing tree destruction, involving under storey removal (a), pruning and tilling (b), killing of pruned trees (c), logged trees for timber within the farms (d), abandoned wood in farmlands (e) and an established farm where all dried up destroyed trees had been cut down and used for fuel wood (f) in the mountain forest of the MCR

A total of 460 trees of dbh ≥ 10 cm belonging to 98 species and 33 different families were damaged (184 trees damaged/ha). The highest record of damaged trees was 44 plants of the Malvaceae family. The total basal area loss of trees under damage was 422.1 m2 in the 2.5 ha. The most important species were Terminalia superba, Xylopia africana, Entandrophragma cylindricum, Hymenostegia afzelii and Ceiba pentandra which possessed IVI 15.8, 13.1, 12.1, 11.4 and 10.4 respectively. The altitude ranged from 87 m msl in Bimbia to 1,062 m msl in Bokwango. The highest numbers of tree destruction was 61 trees per 0.25 ha in Bonakanda. But the highest basal area loss was 97.4 m2 per plot in Bimbia. Mean destruction was 46±2.6 trees per 0.25 ha plot, and mean BA was 58.5±8.0 m2 in the study area (Table 4).

Basal area loss was 266.9 m^2 per ha in the coastal forest while it was 225.9 m^2 per ha in the montane forest. Average destruction was 188.8 trees per ha in the coastal forests and 146 trees per ha in the montane forest. The t-test showed that there was no significant difference in the cumulative basal area loss from both sites at 95% probability level (Fig. 2).

Altogether 207 trees were destroyed which have dbh class 10-30 cm. Out of this, 115 trees were from the coastal forest and 92 from the montane forest. In case of 31-60 cm dbh class, 77 trees were destroyed from the montane forest and 54 from the coastal forest. Diameter classes between 120 to 150 cm, had a total of 12 trees destroyed (2.6%), 7 of these in the montane forest and 5 in the coastal forest (Fig. 3).

Table 4. Tree destruction and basal area loss in ten 0.25 ha plots in the study villages of MCR

Locations of farms (sites)	Elevation (ma sl)	No of trees damaged (0.24 ha)	Mean n° of trees amaged (±2.6)	Basal area loss (m^2)	Mean basal area loss (±8m^2)
Bokwango	1062	43		43.23	
	1001	30	36.5	21.12	32.18
Bova	1108	49		67.24	
	986	40	49.0	60.86	
Bonakanda	959	61	50.5	88.62	38.57
Bimbia	87	43		75.75	
	95	55	49.0	97.41	74.74
Idenau	102	49		78.55	
	115	45		40.90	
	104	44	46.0	41.01	86.58
Total		460	46.0	614.39	58.50

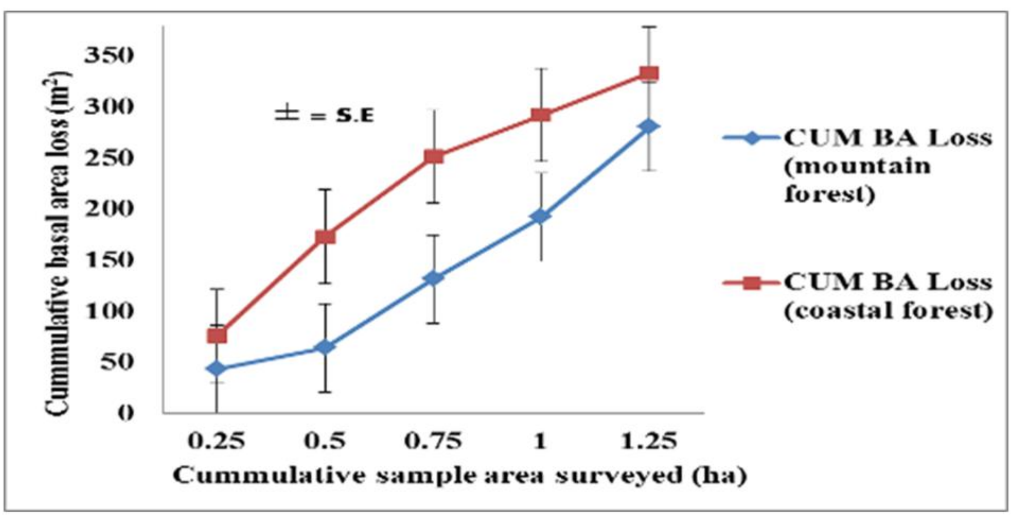


Fig. 2. Cumulative basal area loss in the coastal and montane forest in the study sites

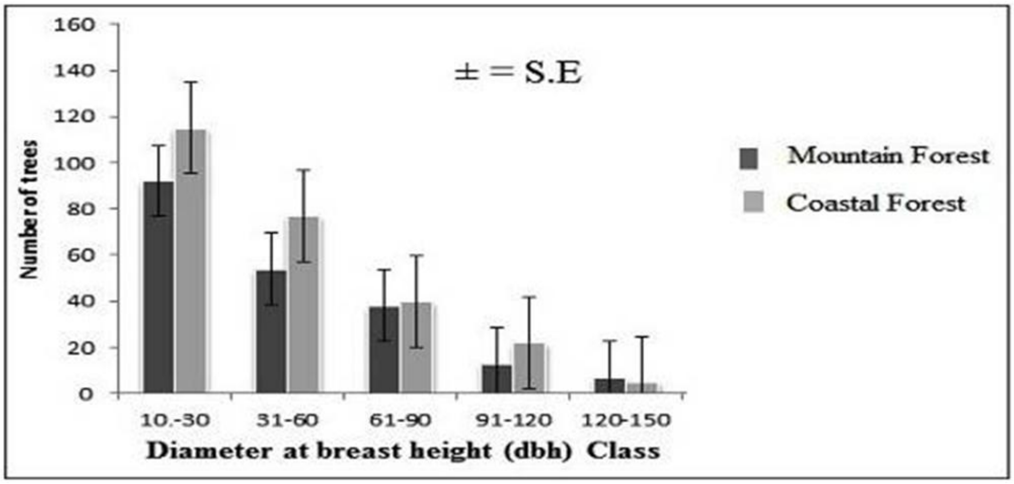


Fig. 3. Diameter class of trees destroyed in the Montane and coastal forest

4. DISCUSSION

4.1 Farming Practice in the MCR

Farm lands were the major land use, which was also reflected in the occupation of the respondents with majority of them being farmers. The high level of farming may be attributed to the presence of fertile volcanic soils. Tourism and forest reserve land uses were low. This was most likely due to increased farm lands and settlement areas.

The uses of land keep changing, as is land tenure, as indigenes sell farmlands that were left to fallow and the new owners construct houses there. Households with high education levels still depended on the forest and farms for their livelihood. This was most probably caused by poverty, unemployment and under employment. This finding is contrary to those of [30] who reported that African households with higher education levels have more reliable sources of income and do not depend on the forest. High dependence on natural forests has caused forest degradation and the forest is no more continuous at low and high elevations, but broken by ‘new lay outs’ and towns, contradicting the view of [31] who reported that this forest was the only unbroken vegetation at 200 to 4,000 m asl in West and Central Africa.

Fallow periods were short and there were no long term fallow rotation periods. This drop in fallow period is most likely attributed to land scarcity and increased population. This finding is not in conformity to those of [32] who reported fallow periods of 10 to 16 years in the MCR. Most newly opened farms as a result of shifting cultivation were inside the forests and forest edges, contributing to forest cover loss.

4.2 Forest Cover Change Pattern

About 77.5% ground truth points were matched with the classified maps. This means, about 22.5% points were not matching, probably a result of disturbances in classification due to confusion of cloud and trees. In addition, also it was not easy to classify the image because of small farm lands in the forests. Five classes were chosen for this classification to obtain a high accuracy in the assessment. This was due to the inability to clearly separate green vegetation that occurred as forest from savannah and other vegetation types. An assortment of unrelated objects shared the same reflectance band which made it difficult to separate them during analyses. Even though the reflectance of the plantation types was similar to that of forest, it was easier to identify them and put them in a separate class because they appeared as little polygons and rectangles based on the manner in which the crops were grown. Settlement on its part was easily distinguished because it had a distinct reflectance different from vegetation type. However, due to the resolution of the images used (30 m), it was difficult to separate bare soil, roads and gardens from the built-up area, thus they were also grouped together in the settlement class. For mangrove, even though it had a greenish reflectance, it was characterised by little water bodies within it, that made it distinct and easier to identify.

The annual forest cover loss was 21.8 ha between 1986 and 2000 in MCR but the agricultural fields were less between 1980s and 1990s due to expansion of plantations (2), [33], lava flow (3) and urban development [34]. The annual deforestation dropped to 9.8 ha (0.58%) between 2000 and 2008. This decrease trend of deforestation between the two periods may be due to conservation efforts by the Mount Cameroon Project (MCP), several Non-Governmental Organizations (NGOs), German Agency for Technical Cooperation (GIZ), and the creation of community forest reserves like Bimbia Bonadikombo Community Forest Reserve (BBCFR), Woteva community forest, Bakingili/Etinde community forest and Scipio Council Forest Reserves. This annual deforestation percentage is similar to that of Central Africa (0.5%) reported by [35] and that of Cameroon for the 1990s (0.6%), reported by (9). This continual loss of forest probably has a serious effect on carbon balance and climate change mitigation.

There was continual annual increase in settlement areas within the two periods. The increase in settlement between 1986 and 2008 may be due to increase in populations. According to reports by Kai (20) and WWF (21) the population increase was about 4,375 persons per year between 1987 and 2000 and about 10,000 persons per year from 2000 to 2010. The resultant effects were construction of more houses and creation of more new-lay-outs for settlement. However, the decrease in agricultural fields between 2000 and 2008 was most likely due to the surrender of plantations done by the CDC for urban development and sale of some small scheme plantations and farms for new owners who changed the use of the land from agriculture fields to house constructions.

4.3 Destruction of Trees in Farms

The first stage of farm preparation when new farms were opened was the removal of the under storey and killing of trees. This was most likely to increase the space for planting crops and to minimise shade effects. The same trend was identified by [36] who reported that few dominant trees were felled during the preparation of small scale subsistence farms (0.5 to 2 ha) in the forests of the MCR, which contributed to deforestation and loss of biodiversity. Wright [37] reported that the under storey was home to juveniles for canopy trees and life stages of small trees, shrubs and herbs. The removal of this vegetation cover therefore affects the ecosystem balance and alters habitats. Such habitat alterations cause biodiversity loss, lowers pollination, limits dispersal and increases seed predation. Bobbo et al. [38] also reported that tree species richness decreased significantly with increased levels of habitat modifications in South Western Cameroon forests. According to Lawton et al. [39] such modifications of habitats reduced species richness of birds, butterflies, beetles, ants, termites and nematodes in tropical forests, which are agents of pollination, and thus habitat modifications are a threat to biodiversity.

Tree destruction was high in the coastal and montane forests. The reason behind this may be easy accessibility of the forests and high demand for fuel wood. Basal area losses were high. This finding was also supported by [38,40]; they reported tree basal area loss was due to conversion to farmlands from forests in South Western Cameroon. Loss of tree standing biomass negatively impacts the CO_2 balance and climate change mitigation.

Higher loss of tree numbers and reduction in basal areas was found in the coastal forests compared to montane forests. The reason was greater access to the coastal forests. This result was also supported by [41] who studied stand biomass of trees in the coastal and montane forests of the MCR and recorded 99 trees per ha (dbh ≥ 50 cm) in the coastal forests and 92 trees per ha in the montane forests of the region in 1989. According to Vazquez and Givanish [42] basal areas and tree densities decreased at low elevation than that of higher altitudes; though (41 saw little evidence of effects of elevation on species richness and growth rate from low to high elevation.

The result showed a higher loss in dbh class 10 – 30 cm. This massive loss was because the forest is a secondary one, recovering from anthropogenic impacts and disturbance caused by larva eruptions from Mount Cameroon.

Higher destruction was recorded in Malvaceae family, probably because this species was dominant in MCR. This was also supported by Watts and Akogo [43] and Tako et al. [44]. They noted these species thrive in gaps created by past lava flow in MCR. Ecologically, *Terminalia superba* (White afara), *Xylopia africana*, *Entandrophragma cylindricum* (Sapelle), *Hymenostegia afzelii* and *Ceiba pentandra* (Boma) were the most important species destroyed because people prefer these species for furniture wood, construction materials, fuel wood and medicine. According to Broklesby and Ambrose [45] and Forboseh et al. [41] *Hymenostegia* spp. was one of the dominant species in the montane forests of the MCR, while *Entandrophragma* spp. and *Ceiba pentandra* were culturally important and highly used species in the region.

5. CONCLUSION

From our studies, the following conclusions can be drawn:

Land use changes particularly agricultural intensification with high dependence on natural fertile soils favoured shifting cultivation, leading to loss of forest cover in MCR.

There was massive tree destruction during the opening of new farms inside the forest, as well as fuel wood collection which is detrimental to the plant and animal diversity supported by the forest in the MCR.

6. RECOMMENDATIONS

Based on findings of this research, the following are recommended:

- The boundary of forest reserves should be well traced, and areas for farming properly carved out, with sign posts to show forest reserves and farming areas.
- Alternative livelihoods options that do not depend on extensive land use can be promoted in this sensitive region to reduce pressure on natural forests.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ravindranath NH, Manuvie R, Fargione J, Pep Canadell, Goran Berndes, Jeremy Woods, Helen Watson, Jay Sathaye. GHG Implications of Land Conversion to Biofuel Crops. Scope Biofuel Report FAOSTATS. Accessed 26 September 2014; 2010. Available: www.fao.org/metadata
2. Sunkekang RM. Forest Policy: Forest loss and land use cover change in cameroon. PhD thesis, Oklahoma State University; 2006.
3. Kah EF, Tchindjang M, Tonye E, Talla TN. Combined supervised classification methods in Remote Sensing for the Evaluation of forest Dynamics along the slopes of Mount Cameroon. The Int. Arch. of Photogrammetry, Remote Sens. and Spatial Info. Sci. 2008;37:8.
4. Sayer JA, Harcourt CS, Collins NM. The conservation atlas of tropical forests. Tropical Ecology. 1992;43(1):9-20.
5. Chapin F, ZavaLeta E, Viner V, Naylor R, Vitousek P, Reynolds H, Hooper D, Lavorel S, Sala O, Hobbie S. Consequences of changing biodiversity Nature. 2000;405:234-242.
6. Luck GW, Ricketts TH, Daily G, Imhoff M. Proc Nat. Acad Sci USA. 2004;101:182-186.
7. Fonge BA, Yinda GS, Focho DA, Fongod AGN, Busman RW. Vegetation and soil status on an 80year old lava flow of Mt Cameroon, West Africa Lyonia J. of Ecol. and Appl. 2005;8(1):19-41.
8. ERM (Environmental Resource Management). Environmental impact assessment of plantation expansion by Cameroon development cooperation in forested lowland of the mount Cameroon region. A report prepared for MCP, Limbe and DFID London. 1998;166. Available: http://www.academia.edu/
9. FAO. (Food and Agricultural Organization). Changes in shifting cultivation in Africa. FAO Soils Bulletin, 24, FAO Rome, Italy; 1985. Ecology and rural education - Manual for rural teachers. 1995(ES);122.
10. Donald PE, Sanderson FJ, Burfield IJ, Van Bommel FPJ. Further evidence of continent wide impacts of agricultural intensification on European farmland birds. Agric. Ecosyst. and Environ. 2006;116: 189-196.
11. Wilson JD, Morris AJ, Arroyo BE, Clark SC, Bradbury RB. A review of the abundance and diversity of invertebrate and plant foods of gravinovorous birds in Northern Europe in relation agricultural change. Agric. Ecosyst. and Environ. 1999;75:13-30.
12. MEA (Millennium Ecosystem Assessment). Ecosystem and human well-being. MEA, Island Press Covelo C.A; 2005.

Avialable:http://www.millenniumassessment.org/documents/document.356
13. Tohru K, Kimiko O, Ian T, Ken S, Takeshi T, Kazuyuki F. The role of forest Biodiversity in the sustainable use of ecosystem goods and services in agro-forestry, fisheries and forestry. proceedings of international symposium for the convention on biological Diversity, Tokyo Japan; 2010. Available:http://www.ffpri.affrc.go.jp/en/symposium/20100426
14. Mckee JK, Sciuilli PW, Fooce CD, Waite TA. Forecasting Global Biodiversity Threats Associated with Human Population Growth. Biol. Conserve. 2003;115:161-164.
15. Rimm SL, Raven P. Biodiversity: Extinction by numbers. Nature. 2000; 403:843-845.
16. MEA (Millennium Ecosystem Assessment). Biodiversity and human well being. Biodiversity Synthesis. Island Press; 2005. Available:http://www.millenniumassessment.org/documents/document.356
17. Chamberlain JL, Cunningham AB, Nasi R. Diversity in forest management: Non-Timber Forest products and bush meat. Renewable Resources J. 2004;11-19.
18. Fomete NT, Tchouto MG. Mont Cameroun, la gestion des ecosystems forestiers du Cameroun. A laube de l'an 2000 (Eds). 1998;127-144.
19. Fraiser PL, Hall JB, Healey JR. Climate of the Mount Cameroon Region, long and medium term rainfall, temperature and sunshine data. SAFS, University of Bongor MCP-LBG, Limbe. 1998;1-56.
20. Kai Schmidt-Soltau. Rural livelihood and social infrastructure around Mount Cameroon. GmbH Back ground information for the M.C-SE GIS; 2003. Available:http://www.esf.edu/efb/gibbs/efb413
21. WWF (World Wide Fund for nature). Central African 2010 fact sheet, Mount Cameroon National Park, panda. Org. 2010. In Muambo and Pedro. An application of geographic information systems to model the habitat suitability of Pan troglodytes ellioti in Mount Cameroon National Park in the context of a changing global climate. 2014;108(1):63-79.
22. Cable S, Cheek M. The plants of Mount Cameroon. A conservation check list royal botanic garden kew, London; 1998. Available:http://press.uchicago.edu/ucp/books/book/distributed/P/bo9115678
23. Akinwumi AA, Mbila D, Nkamleu DBG. Econometric analysis of the determinants of adoption of alley farming by farmers in the forest Zone of South West Cameroon. Agric. Ecosyst. and Environ. 2000;80:255-265
24. Cogolton RG. A review of assessing the accuracy of classification of remotely sensed data, Remote Sens. of Environ. 1991;37:35-46.
25. Mueller-Dombois D, Ellenberg H. Aims and methods of vegetation ecology. John Wiley and sons New York. 1974;337.
26. Tiwari SC. Concepts of Modern Ecology. Vegetation. 2005;85:17-120.
27. Diogo SB, Leiton SD, Flavo F. Adaptive success index; A criterion for identifying most important species. J. of Ecol. and the Nat. Environ. 2010;2(11):259-260.
28. Trotter CM. Characterizing the topographical effects at red wavelengths using juvenile conifer canopies. Int. J. Remote Sens. 1998;19(11):2215-2221.
29. Bokye E, Odai SN, Adjei KA, Annor FO. Land sat images for assessment of the impacts of land use and land cover changes on the berekesse catchment in Ghana. Euro. J. of Sci. Res. 2008;22(2):219-278.
30. Kamanga P, Vedeld P, Sjastad E. Forest incomes and rural livelihoods in Chiradzulu District Malawi. Ecol. Econ. 2009;68(3):613-624.
31. Thomas B, Check M. Vegetation and plant species on the south side of mount Cameroon in the proposed Etinde Rainforest Reserve. Report to Cameroon Government/OD A/ RBG, Kew. 1992;37.
32. Ardener E, Ardener S, Warnington WA. Plantations and villages in the cameroons. Some economic and social studies, Oxford University Press, Oxford In: Ambrose-Orji B, Acworth J, Abonge G, Manga H (1998): Rapid Agricultural Surveys Methodology notes. MCP, Limbe. 1960;15.
33. Siwe RN, Koch B. Change vector analysis to categorise land cover change processes using the tessellated cap as biophysical indicator, description, implementing land sat TM and ETM to defect land cover and land use changes in the Mount Cameroon Region, using the CVA technique with the tasselled cap as biophysical indicator. Enviro. Monit. Assess. 2008;145:227-35.
34. Njohjam PN. Integration of remote sensing and GIS in land use planning for sustainable natural resource management

within the Mount Cameroon Region West Africa. Int. Arch. of Photogrammetry and Remote Sens. Amsterdam. 2000;33:7.

35. WRI (World Resource Institute). World Resources Report, 1994-1995. New York: Oxford. Oxford University Press. 1994;10-33
36. Siwe RN. Evaluating the efficacy of remote sensing techniques in monitoring forest cover and forest cover change in the Mount Cameroon Region. Ph.D. Thesis Albert Ludwig's University, Freiburg ImBreisgam-Germany; 2006. Available:http://webdoc.sub.gwdg.de/ebook/dissts/Freiburg/Ngamabou2007
37. Wright SJ. Plant diversity in tropical forests. A Review of Mechanisms of Species Co-existence Ecologia. 2002;130:1-14.
38. Bobbo SK, Walter MN, Sainge MN, Njokagbor J, Fermon H, Murlenberg M. From forest to Farmland. Species richness patterns of trees and under storey plants along a gradient of Forest Conversion in South Western Cameroon. Biodiv. and Conserv. 2006;15:4097-4117.
39. Lawton JH, Bignell DE, Bolton B, Bioemers GF, Eggleton P, Hammond PM, Hodda M, Holt RD, Larsen TB, Mawdsley NS, Srivastava DS, Watt AD. Biodiversity inventories, indicator taxa and effects of habitat modifications in tropical forests. Letters to Nature. 1998;391:72-76.
40. Zapfack L, Engwald S, Jonke B, Achoundong G, Madong B. The impact of land conversion on plant biodiversity in the forest zone of Cameroon. Biodiv. And Conserv. 2002;11:2047-2061.
41. Forboseh PE, Sunderland T, James C, Bainga M. Tree population dynamics of three altitude vegetation communities on Mount Cameroon (1989-2004). J. of Mount. Sci. 2011;8(4):495-504.
42. Vazquez GA, Givanish JT. Altitude gradients in tropical forests composition, structure and diversity in the Sierra de Mananthlan. J. of Ecol.1998;86:949-1020.
43. Watts J, Akogo GM. Biodiversity assessment and developments towards participatory forest management on Mount Cameroon. The common wealth forestry review Oxford. 1994;73(4):221-230.
44. Tako C, Mojoko S, Ekema D. (Eds). User group analysis for participatory forest management in Bwassa, Likombe, Mapanja villages. Mount Cameroon Project (MCP) Limbe. 1996;21(2):609.
45. Broklesby MA, Ambrose-Oji B. Neither the forest nor the farms. Livelihood in the Forest Zone, the role of shifting agriculture in Mount Cameroon Rural Development Forestry Network Paper 12/d summer. 1997;24.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=765&id=5&aid=7221