The Environmental and Socio Economic Signatures of Landcover and Landuse Dynamics in the Ndu Tea Estate, North West Cameroon

Ndi Roland Akoh [a*], Nfor Kevin [b] and Ojuku Tiafack [a]

[a] *Department of Geography, Faculty of Arts, Letters and Social Sciences, The University of Yaounde I, Yaounde, P. O. Box 755, Cameroon.*
[b] *World Resources Institute, Cameroon.*

Authors' contributions

This work was carried out in collaboration among all authors. Author NRA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NK and OT managed the GIS analyses of the study. Author OT managed the literature searches. All authors read and approved the final manuscript.

Article Information

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ABSTRACT

Land is a fundamental factor of production and thus the source of all forms of material wealth. For a sustainable utilization of the land resources, it is essential to know its natural characteristics, extent, location and limitations of various land uses as improper land use is the cause of different forms of environmental degradation. This paper sets out to quantitatively analyze the spatio- temporal dynamics of landcover and landuse patterns in Ndu Sub-Division with emphasis on land for tea cultivation in a bid to provide useful information to stakeholders on the environmental and socio economic signatures. The methodology consisted of three phases; the first phase handled data acquisition, vectorization and satellite image processing. This was followed by field work, aimed at verification of ground truth, collection of GPS waypoints, GPS tracks and attribute data. The third phase consisted of post field activities, comprising of restitution and validation of data, map production and analysis. The findings show that between 1988 to 2018, Ndu Sub Division experienced a drop in farmlands and savanna vegetation by 1.9% (from 60882.7 to 58616.6ha)

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

while forests, built-up areas, tea parcels and small holder schemes witnessed an increased by 1.1% (18109.7 to 18500.9ha), 39.7% (13184.4 to 3051.5ha), 5.2% (619.85 to 688.27ha) and 100% (0 to 73.2ha) respectively. Such dynamics have been accompanied by both positive and negative imprints. On the positive side, the Ndu Tea Estate is a catalyst in rural livelihood transformation and development. The participation of the local populations in the activities of the estate has led to income improvement and poverty alleviation. However, land tenure disputes, labour abuse characterized by low wages, poor living conditions for unskilled workers and job insecurity are glaring. On the environmental side, bush fires, environmental pollution through chemical spraying, fertilizers and deforestation are common.

Keywords: Landcover; landuse; environmental; dynamics; tea; cultivation; Ndu.

1. INTRODUCTION

Land is a fundamental factor of production and thus the source of all material wealth. The availability of land is the key to human existence as its distribution and uses are of vital importance [1]. Throughout the course of human history, land has been very significant for economic growth. Population growth is one of the paramount drivers for increasing pressure on land for agriculture and settlement. This pressure results in unplanned and uncontrolled changes in land cover and land use [2]. An important first step to ensuring a balance between cropland expansion and environmental degradation is the accurate mapping of croplands as well as crop types on a regular basis [3,4,5]. Agricultural land use mapping (mapping spatial distribution of crops or crop mapping) can benefit a wide range of biophysical and economic models that assesses the impacts of agriculture on the environment and vice versa. For example, simulation models that integrate climate and crop data to assess climate change impacts on crop yields have become popular in recent years [6,7,8,9]. Most of these studies, however, lack explicit information on the spatial distribution of crops under investigation [8] and [9], or rely on approximations to identify the possible location of crops in the study area [6] and [7]. Additionally, the scale of maps used is often too coarse to allow applicability in local level analysis. In this regard, the provision and utilization of accurate and up-to-date agricultural land use maps can assist in better identifying priority areas (due to spatial and temporal variation in crop response to climate change) and improve targeting of policy interventions. For a sustainable utilization of land resources, therefore, it is essential to know its natural characteristics, extent and location, quality, productivity, suitability and limitations of various land uses. In order to appropriately monitor the changes in croplands and assess its impact on the ecosystem and other environmental processes, standard, accurate and up-to-date information on agricultural land use is required [10]. Available data on landcover and landuse changes can, therefore, provide critical input towards decision-making for environmental planning and management [11].

Land use and land cover changes are amongst the most significant human modifications to the earth's terrestrial surface [12]. Land cover refers to the natural and man-made coverings on the earth's surface such as vegetation, soil and water; while land use is the exploitation of the earth's biophysical attributes by humans for a particular purpose [13]. These changes have negative impact on ecosystems and environmental processes at local, regional and global scales, threatening the capacity of the earth's ecosystems to provide the required goods and services [13]. Land use mapping which ensures that land is used and managed sustainably is thus increasingly becoming an important tool in decision making today as it provides the necessary information in relation to the pattern, the use of land resources as well as a basis for land characterization. Land cover/land use maps are thus crucial for establishing links between policy decisions and regulatory actions on subsequent land use activities [14].

Cameroon also known as 'Africa in miniature' [15] has fertile soils which favour both commercial and subsistence agriculture. The commercialization of agriculture in Cameroon with the opening of large-scale plantations have had a great impact on peasant agriculture especially with the advent of innovation diffusion technics. This is the case of tea cultivation, which over the years stood out as one of the most important sources of livelihood. These plantations have developed the areas where they are located through poverty alleviation and improvement of living standards of the population as well as social and infrastructural development.

The Ndu tea estate is an agro- industrial complex that cultivate and transforms tea from green leave to made tea. The estate has become a magnetic force that pulls people from neighbouring villages, Sub-Divisions, Divisions, and other regions of Cameroon.

Based on the above discussions so far, the rationale for undertaking this research is anchored on the fact that, standard, accurate and up-to-date information on landuse dynamics within the Ndu tea estate is lacking. This study, therefore, sets out to quantitatively analyze the spatio-temporal dynamics of LULCC structures or patterns in Ndu Sub-Division (NSD) in the North West Region of Cameroon with emphasis on land use for tea cultivation and the related socio economic implications. Considering the importance of agriculture in the economies of most less developed countries such as Cameroon in general and Ndu Sub Division in particular, findings from this study may provide useful information to stakeholders of the agricultural sector, to adequately understand the importance of land use zoning and mapping. It may provide information for tea farmers to better manage and prioritize land usage for tea cultivation as well as selecting and adopting land use options which are most beneficial to the different land users in Ndu Sub Division together with the selection of measures most likely to encourage such land uses. Besides, the study could also be crucial in establishing links between policy decisions and regulatory actions on subsequent land use activities.

2. MATERIAL AND METHODS

2.1 The Study Area

Ndu Sub Division (NSD) is located between longitudes 10.5° and 11° East of the Greenwich Meridian and latitudes 6.2° and 6.5° North of the equator (Fig. 1). It was created by presidential decree No. 93/322 of 25/11/1993 and constitutes one of the five sub divisions in Donga Mantung Division of the North West Region of Cameroon. It is situated some 140km North East of Bamenda (North West regional capital) and about 40km south of Nkambe (Divisional headquarters of Donga-Mantung). Ndu Sub division is bounded to the North by Nkambe, to the south by Mbiame (Bui Division), to the South-West by Nkum Sub Division (in Bui Division), west by Noni Sub Division (in Bui Division) and to the East by Nwa Sub Division. Its position is central to Nwa, Kumbo Central and Nkambe Central Sub Divisions [16]. This central location

is an important factor for sources of labour and ready markets for tea from the Ndu Tea Plantations.

Ndu Sub Division occupies a surface area of 1625 km^2, with a population of 85,048 inhabitants, giving it a population density of 45.51 persons/km^2 [16]. NSD has a diverse physical environment, characterized by hills with more or less steep slopes as well as valleys and plains, drained by streams of various sizes. The soils of NSD are mainly humid ferralitic soils of the high lava plateau of the North West Region of Cameroon whose formation are controlled by the parent material, altitude, topography, climate and human activities.

2.2 Historiography of the Ndu Tea Plantation

Tea was brought into Cameroon in late 19th century by the Germans. Seeds were planted at the Limbe Botanic Garden which was a host to all plant species in Africa at the time. By 1928 tea was introduced on small trial plots with a total of 26 hectares in Tole at the foot of Mount Cameroon. Though with very little economic value at the time, these 26 hectares served as a nucleus for tea planting in Cameroon. It was later diffused to other parts of the country such as Ndu and Djuttitsa through the creation of tea estates. The Ndu tea estate was owned by a British-Indian multinational company known as Estate and Agency Company Ltd (EAC). The estate was later handed to the Cameroon government following the departure of the British from Cameroon after the Second World War and placed under the control of the Cameroon Development Corporation (CDC). Due to mismanagements which brought about a substantial fall in output, it was privatized to the Cameroon Tea Estates (CTE) which now owns and manages the Tole, Ndu and the Djuttitsa tea estates.

2.3 Stakeholders of Tea Cultivation in Ndu Sub Division

Stakeholders of tea cultivation in Ndu include; the custodians of land (traditional rulers and village land owners), and most importantly the Cameroon Tea Estates (CTE) - Ndu and small holder tea farmers who cultivate tea thanks to the existence of Ndu tea estate. Tea cultivation has become an important livelihood activity to the people of NSD in particular and Cameroon in general. Its important economic value has created stiff competition amongst tea farmers.

The end result is illegal expansion in tea plots. The major stakeholders involved in the actual cultivation of tea in NSD are the CTE and small holder tea farmers.

2.3.1 The Cameroon Tea Estates (CTE) – Ndu

CTE is the major stakeholder of tea cultivation in NSD. The estate covers a surface area of 1,564.58 hectares of land, with tea cultivated on 688.79 hectares. She produces the largest quantity of tea in this sub-division. Her tea is processed and sold both locally and internationally and it was discovered to be one of the best in the international market by virtue of its very good aroma. The CTE is well structured administratively with clear objectives.
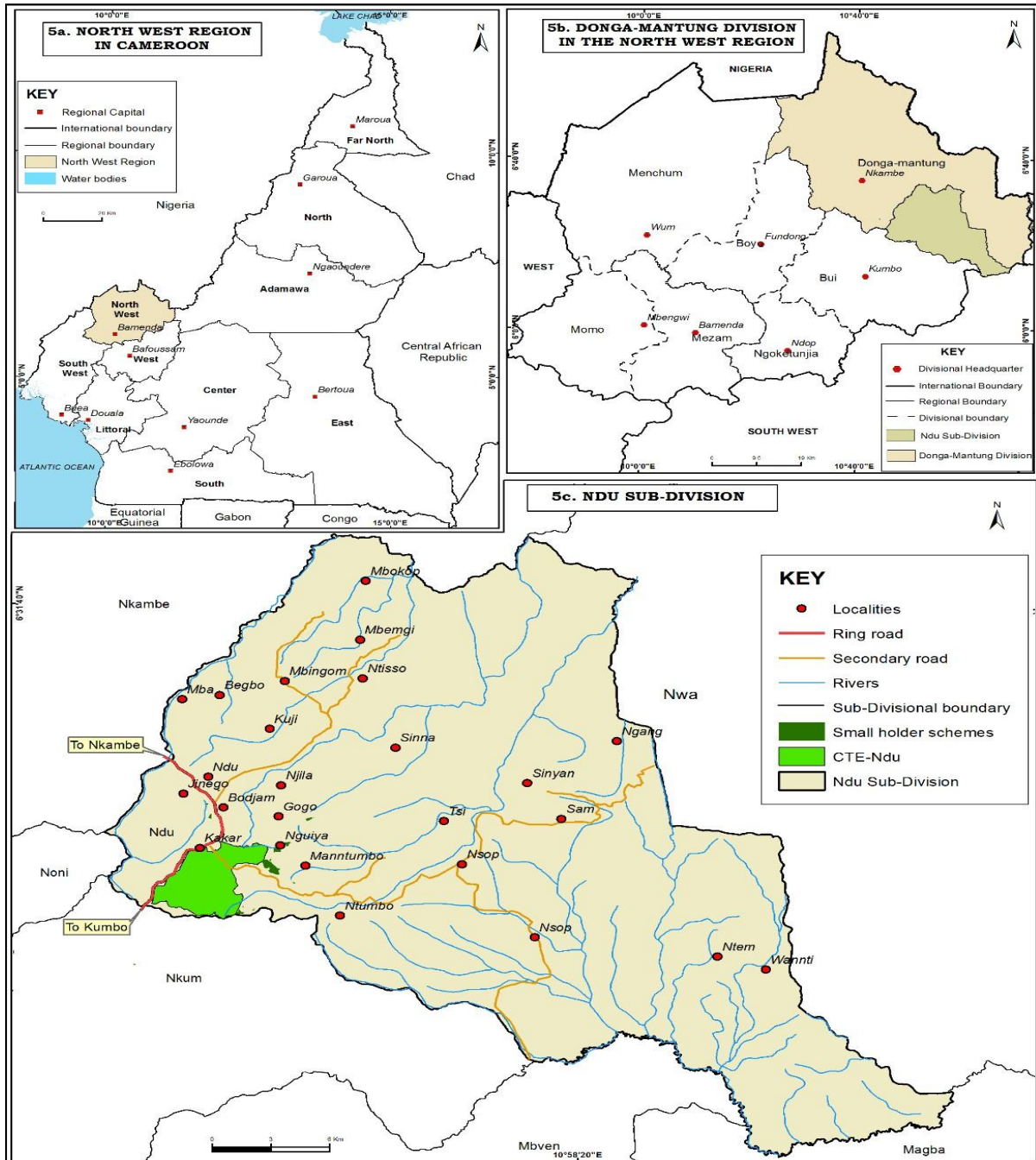

Fig. 1. Location of Ndu Sub Division in the North West Region of Cameroon
Source: National Institute of Cartography (2018)

119

2.3.2 Small Holder Schemes (SHS)

Small holder schemes are mostly indigenes who cultivate small hectares of land, managed by households where tea is either processed locally or sold as green leaves to the CTE. It was introduced and encouraged by authorities of the Ndu tea estate in the early days of the CDC through the innovation diffusion technic, but more of it resulted from the challenges faced by farmers after the privatization of the Ndu tea estate to CTE. There exist different categories of small holder schemes in NSD - those who cultivate tea and sell as green leaves to CTE, independent tea farmers, and tea farmers who have grouped themselves into cooperative unions with harmonized production technics where they cultivate, process and sell their tea in the local market.

2.4 Research Methods

Data for this study was derived from varied sources. This includes GPS waypoints, tracks, photos, digital globe image of 2018, Landsat images of 1988 and 2018, shape files from the Cameroon National Institute of Cartography (NIC) and Statistics gotten from archives of the Cameroon Tea Estates (CTE) and Small Holder Schemes (SHS). In order to better understand how land has been used in NSD, data was processed in two ways. Firstly, a classification of Landsat images aimed at showing the various degrees of land use dynamics was done using ENVI 4.5. Secondly the extraction of data with the aim of mapping tea plots and showing their spatial distribution was done from the 2018 digital globe image through digitization. This was followed by the collection of field data for analysis and mapping. Results obtained include; land use maps showing spatial representation and evolution of the different land uses.

2.4.1 Landsat Image Processing

To process Landsat images, a multi-temporal, multi-spectral and multi resolution range of imagery from different sensors with the same band combination and pixel resolutions was used. The choice of images was based on the availability of data capable of producing land use changes with the most desired results. The observation periods chosen for this study were 1988 and 2018. The choice of 1988 corresponded to the period when the Ndu Tea Estate was the lone tea cultivator in NSD. The second observation period (2018) is the most recent image through which changes in land use were easily noticed. Landsat Thematic Mapper (TM) image, remotely sensed on the 2nd February 1988 and Landsat Enhanced Thematic Mapper image (ETM) of 5th February 2018 were used. The choice of these two periods facilitated a comparative analysis of LULCC vis-à-vis tea cultivation in NSD.

An unsupervised classification of the images was carried out for spectral discrimination (Figs. 2a and b). Clusters were created from the statistical properties of the pixels whereby similar statistical properties in multivariate space were grouped to form clusters. Groups of clusters were created from each Landsat image based on the number of land use classes identified for this study. Geographical coordinates for the different classes were introduced into the Global Positioning System device (GPS) for ground truthing and the characteristics of the features corresponding to their spectral signatures were identified and corrected. Based on these verification and corrections, a supervised classification was carried out using a false colour image composition into four classes of land cover and land use for the 1988 image and five classes for 2018 image.
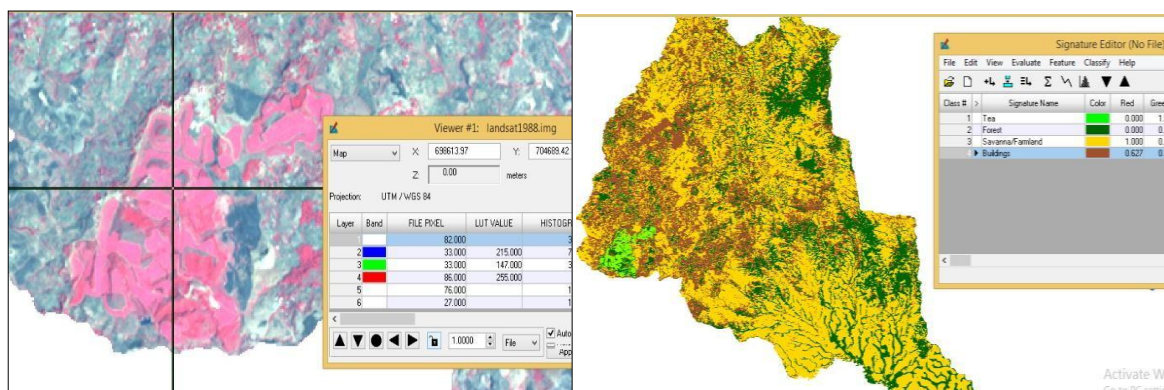

Fig. 2. (a) Unsupervised classification   Fig. 2. (b) Right: supervised classification
Source: Landsat ETM (http://glcf.umd.edu/data/landsat)

Fig. 3. Satellite view of the tea plots in Ndu Sub Division
Source: Digital Globe 2018

For the purpose of the study, the classes sought for were built-up areas, farmlands and savannah, forest, CTE plots and small holder tea plots

2.4.2 Data extraction from digital globe image 2018

The second phase of data processing was done by extracting tea plots from the digital globe image of 2018 (Fig. 3) by means of digitizing thematic layers in the of form keyhole markup language files (kml) and converting them to shape file (shp) extension using Quantum GIS 3.0.0. The reason for choosing this method is to show landuse at a more precise scale.

3. RESULTS AND DISCUSSION

3.1 Landcover and Landuse Change

Based on the sources of data and methods used, two set of results were obtained to show land use dynamics in NSD. The first set of results were obtained from the classification of Landsat image and the second obtained from data extracted from the Digital globe image of 2018. Changes in land use in NSD is explained by analyzing the behavior of different land cover elements. Based on Landsat image classification, the following land use changes were noticed to have taken place in NSD. In 1988, land use was dominated by farmlands and savanna vegetation, since

agriculture is the main economic activity of the people (Fig. 4).

Farmlands and savanna occupied 60882.7 ha of land, forests occupied 18109.7 ha, built-up areas occupied 1318.4 ha, while tea parcels covered 619.85 ha (Fig. 5). During this period, small holder tea farms did not exist because villagers cultivated more of food and other cash crops like coffee, until 1988 when the first small schemes were created.

By 2018 (Figs. 6 and 7), Land use in NSD is noticed to have witnessed a significant change. This is marked by a drop in the surface occupied by farmlands and savanna vegetation from 60882.7 ha to 58616.8 ha. Forest (18500.955ha), built-up areas (3051.41333ha) and tea parcels (688.27ha) witnessed an increase in surface area. The creation of small holder schemes equally brought in a significant change in land use (Fig. 6).

Summarily, between 1988 to 2018, a drop in farmlands and savanna vegetation by 1.9 % was experienced. Forest, built-up areas, tea parcels and small holder schemes have witnessed an increased by 1.1%, 39.7%, 5.2% and 100% respectively (Fig. 8). The increase in eucalyptus on the contrary is as a result of the increasing demand of fuel to process tea as research has proven that eucalyptus is the best source of energy for drying of tea.
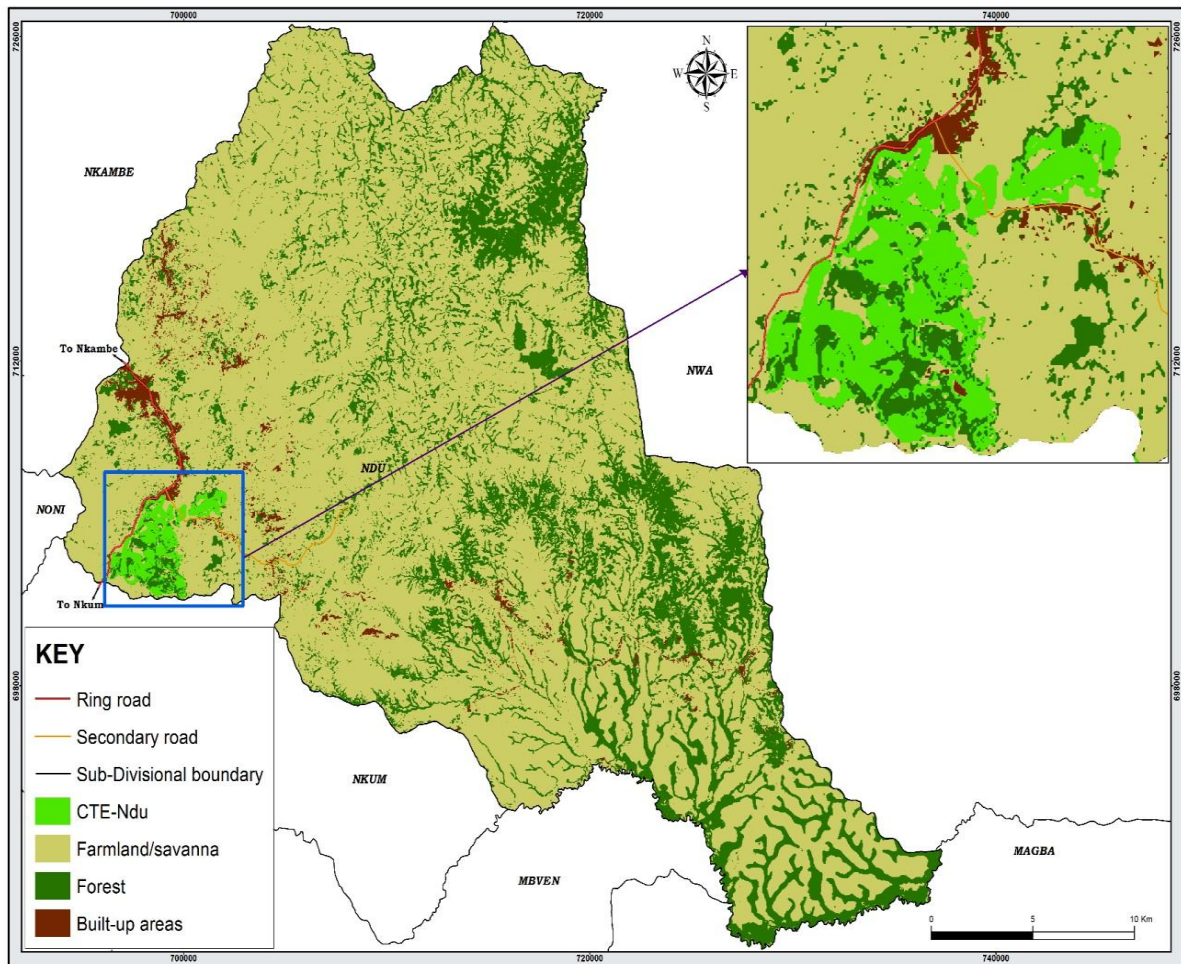
Fig. 4. Land use in NSD in 1988
Source: Landsat TM, February 1988/ National Institute of Cartography/field survey 2018
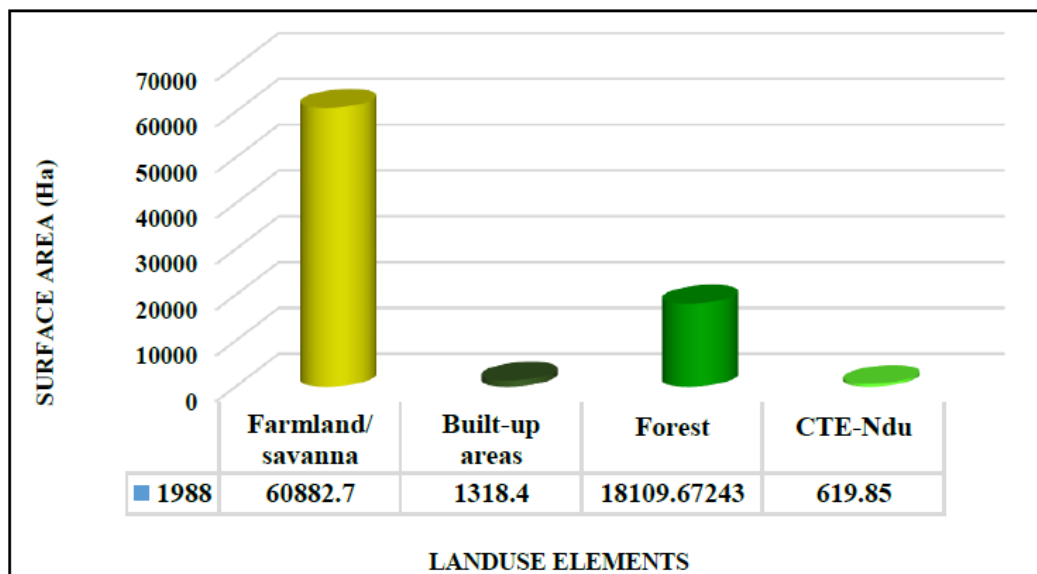

Fig. 5. Landuse in NSD in 1988
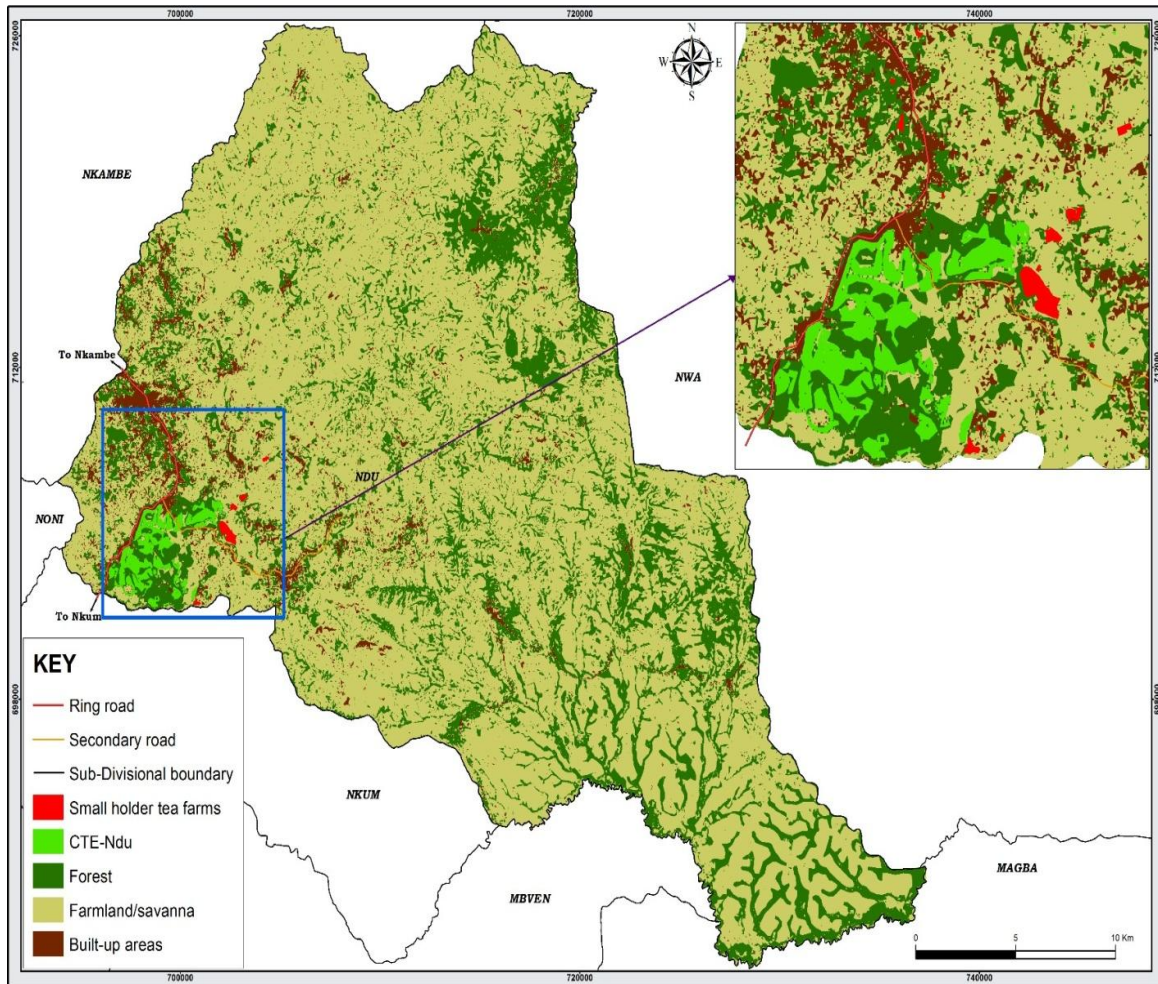*Source: Derived from Fig. 4*

122

Fig. 6. Land use in NSD in 2018
Source: Landsat TM, February 2018/ National Institute of Cartography/field survey 2018

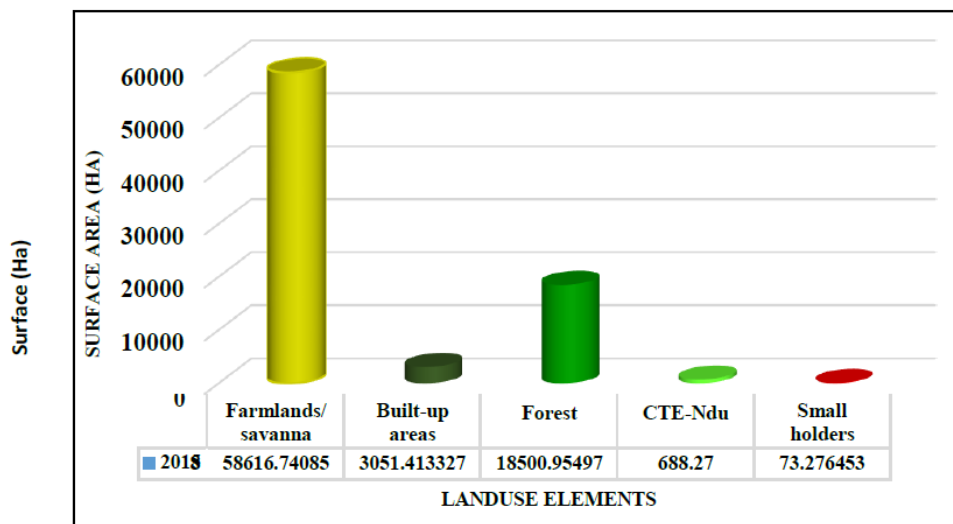
	Farmlands/ savanna	Built-up areas	Forest	CTE-Ndu	Small holders
2018	58616.74085	3051.413327	18500.95497	688.27	73.276453

Fig. 7. Land use in NSD in 2018
Source: Derived from Fig. 6

123
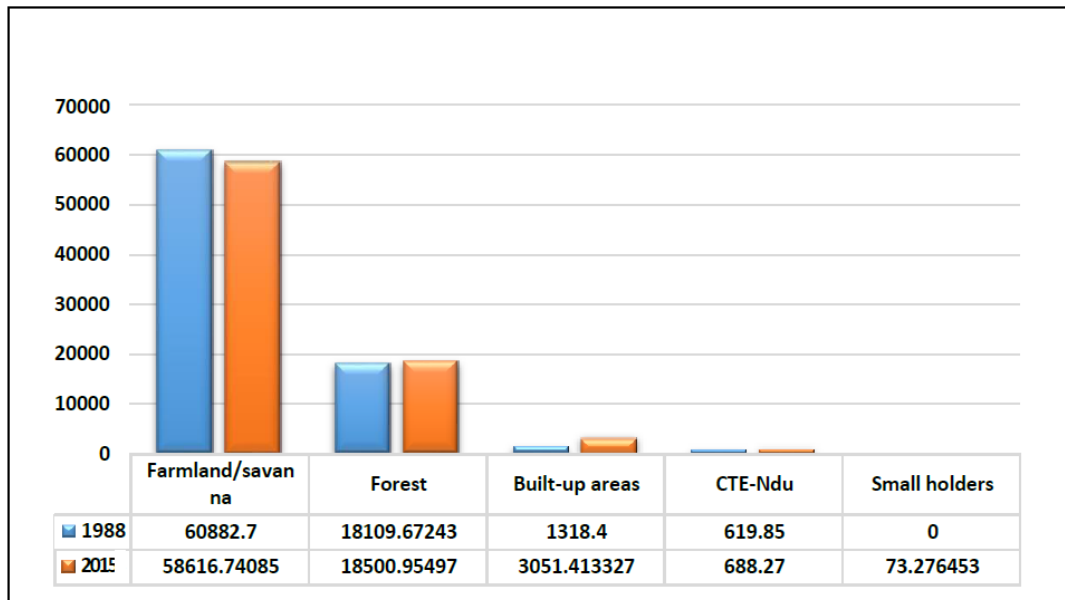
Fig. 8. Summary of Land use changes from 1988 to 2018
Source: Landsat satellite image classification

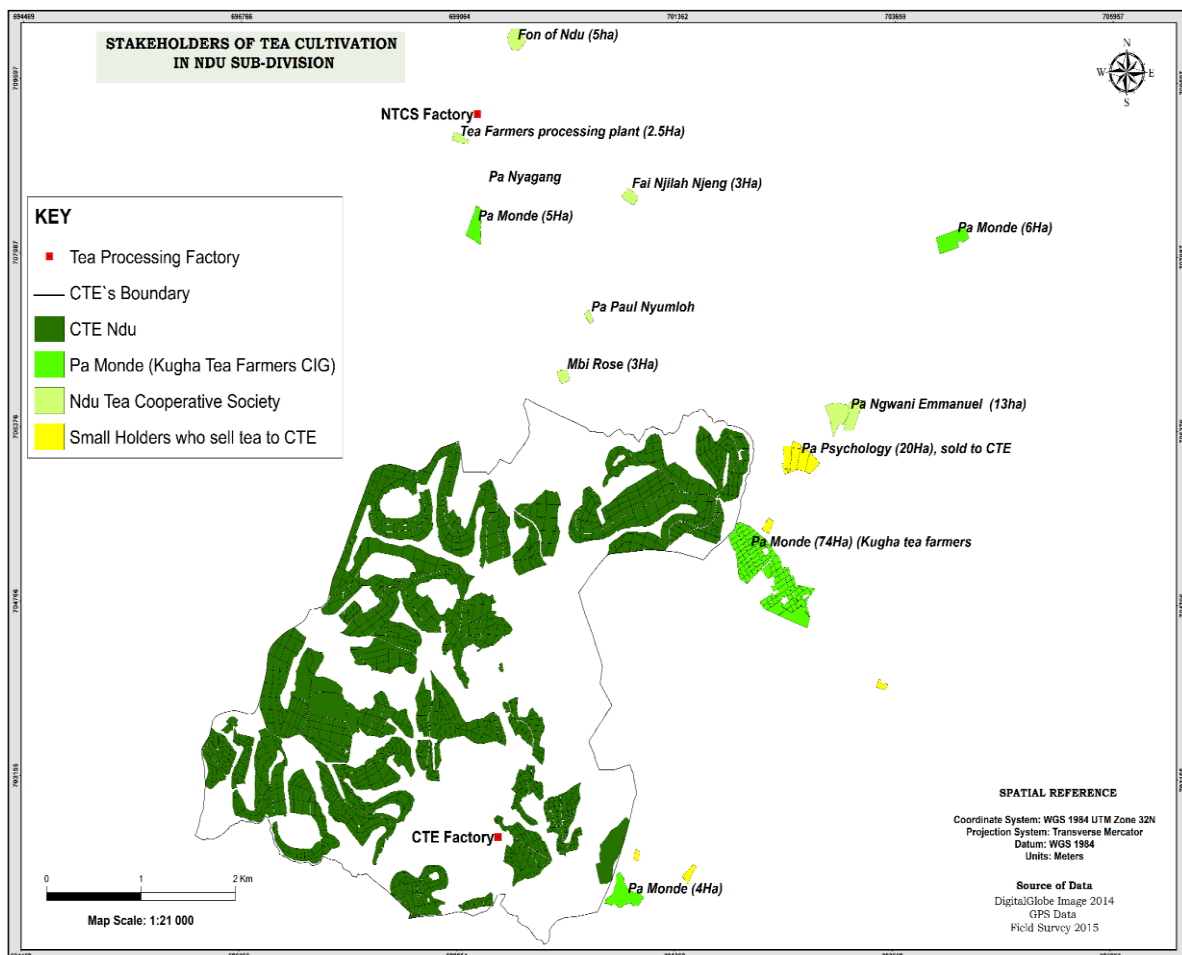|	Farmland/savanna	Forest	Built-up areas	CTE-Ndu	Small holders
1988	60882.7	18109.67243	1318.4	619.85	0
2015	58616.74085	18500.95497	3051.413327	688.27	73.276453

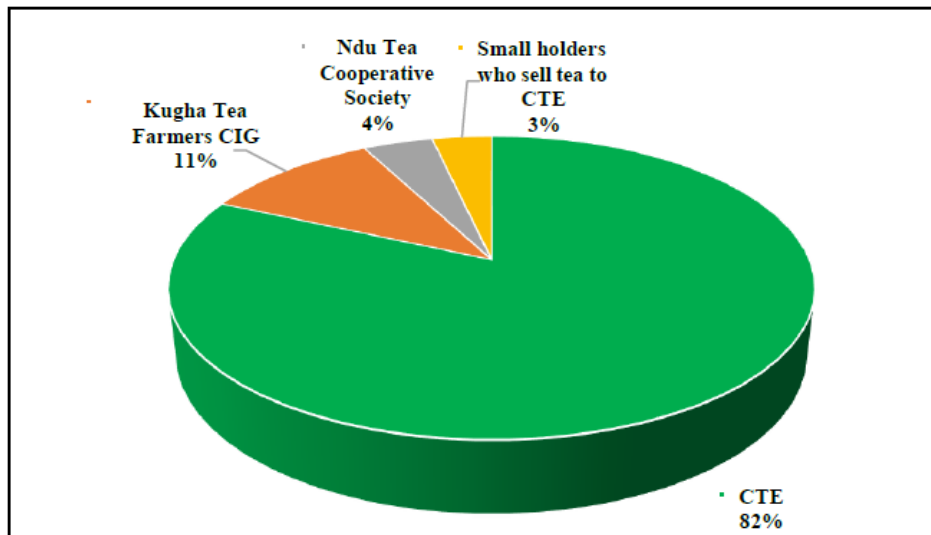**Fig. 9. Tea Estate and Small Holder Tea Plots**

Fig. 10. Tea per stakeholders in percentages
Source: Derived from Fig. 9

3.2 Evolution in Area Occupied by Tea

Results obtained from digital globe image of 2018 data show how land has been used for tea cultivation by the Cameroon Tea Estate and Small holder schemes (Figs. 9 and 10). The Cameroon Tea Estate is the main tea cultivator in NSD, this is seen with respect to the land occupied by tea 668.27ha (82%). On the other hand, small holder tea farms represent 18% of the total tea cultivated area (139.5ha). With a total surface area of 1,584.58 hectares, the CTE Ndu is delimited by well-defined pillars and boundaries and tea plots are characterized into three broad sections (668.27 ha), Eucalyptus (tea fuel) occupy a surface area of 503 ha and unexploited land a total of 387.83 ha. Other land uses are destined for tea nursery (3.98 ha) and infrastructures (1.5 ha). Infrastructures here are comprised of buildings such as residences, factory, workers camps, store houses, canteens, guest house, and guards' services etc.

Small holder schemes have equally had great impact on landuse in NSD. Small holders cultivate tea on a surface area of about 139.5ha, occupying 17% of tea cultivated in NSD with an annual output of 1500 tons of green leave tea a year. Tea produced by small holders is either sold to the CTE as green leaves or it is being processed and sold as made tea. It is worth noting that tea produced by small holders is highly competitive with that of CTE and in most cases small holders have often won the first price from tea exhibitions during agro-pastoral shows.

4. THE IMPACT OF TEA CULTIVATION ON THE DEVELOPMENT OF THE NDU MUNICIPALITY

The cultivation of tea by the Cameroon Tea Estate and small holder tea farmers has brought about significant socio-economic developments in NSD. The impact which is very visible can be evaluated through the number of people employed in the plantations (about 1000 workers), increase in household and council income, infrastructural developments, improvement in the living standards of plantation workers and an increase in the number of people involved in the cultivation and sale of tea nationwide. All this has been made possible through the innovation diffusion process introduced by CDC. Privatisation has also contributed to development and indirectly to an increase in the number of people involved in tea cultivation through the creation of small holder tea farms.

4.1 Economic Impact

4.1.1 Income

Tea cultivation is one of the main source of income in Ndu Sub Division. Prior to 2002, the total amount of money paid to workers monthly as salaries ranged from 35,759,759 to 50,000,000FCFA. This amount, however, dropped to about 11,000,000FCFA upon privatization (CTE archives). The council, the government and citizens of NSD have benefited

significantly from revenue received from the estate. The Ndu Council receives income through taxes levied on tea cultivators. Sources from Ndu Council in 1981/82 showed that about 540,587 and 3,287,300 FCFA was paid yearly as poll and council tax respectively to the treasury. In the year 2000, it increased to 2,000,000 and 4,000,000 FCFA respectively.

4.1.2 Employment

Ndu Tea Estate prior to 2002 was the highest employer in the North West Region of Cameroon with about 1559 workers. The work force is dominated by male labour. Tea cultivation has brought in a diversification of activities which has led to the creation of new jobs. The category of activities offered by tea plantations include tea planting, weeding, clearing, spraying, plucking, transporting, processing, tea packaging, cleaning as well as security guards. Other activities are indirect and include banking services, restaurants services, shops and healthcare services. This finding is similar to those of [17] who noted that plantation agriculture has become a vital source of national income and wealth for many countries. Today the number of people employed in the estate has reduced due to privatization. This view is consistent with the findings of [18] who opined that the layoff of several plantation workers in the South West Region of Cameroon and irregular payment of their wages for several years have rendered these workers unemployed and poor. Today the workers retrenched total about 8000 with calls being made by the CDC for the Cameroon government to put in place strategies to facilitate their reintegration. Privatization has led to the retrenchment of workers, especially those who could not work under the conditions of CTE justifying the view of [19] that the role of plantation in regional development is controversial. Despite this reduction, however, the Ndu Tea Estate remains the major employer in the North West Region besides the Upper Noun Valley Development Authorities (UNVDA). Small holder schemes equally play a great role to employment, with about 150 people employed.

About 90% of the people in NSD currently depend on agriculture as a source of livelihood. The type of crops cultivated are maize, beans, potato, yam, vegetable, tomato, coffee, plantain, and rice. Livestock rearing is also a major economic activity in the area. Livestock here include cattle, horses, goats, sheep, table birds, and fowls. The cultivation of tea has brought in a diversification in agriculture especially as its cultivation has helped farmers to supplement income from other food crops and coffee whose price fell drastically in the international market in 1990. Household involvements in the cultivation of tea has equally boasted the income of many who depended solely on food crops for their livelihood.

4.1.3 Touristic purposes and research ground

The cultivation of tea in Ndu, has projected this Sub-division as a touristic site both nationally and internationally. Tourists from all over the world visit these plantations to observe how tea is cultivated, processed and packaged. It equally acts as a research ground for students at all levels, from institutions all over the national territory. This has brought in income to NSD as many businessmen have invested in tourists infrastructures. Hotels have emerged such as Santana, Summit, Eco-Kid, Dallas, Holy War Complex, Sawa Hotel, Mbiyeh Rest House and George Private Rest House, to host tourists and students who came to visit the plantation.

4.2 Social Impact

4.2.1 Infrastructural development

Tea cultivation in NSD has led to the development of social and economic infrastructures. These infrastructures include banks and micro finance institutions (Ndu Cooperative Credit Union Ltd), restaurants, Camps for workers (Photo 1), shops (Unity shop), schools (Photo 2) churches and hospitals (Ndu integrated health care unit). Other infrastructures include residential houses, improvements in the road network, electricity and water facilities.

These findings have much commonality with [20] who noted that the establishment of plantations in former Victoria Division of Cameroon led to the creation of plantation camps. His findings were, however, different from this current study because according to him, camp life was a melting pot for lumpanism given the fact that labour was being carted from different locations with diverse cultural values and loamed up in plantation camps which set new patterns of life. [21] findings corroborates that of [20] as he averred that camps constructed in plantations were substandard. Such camps according to him camps were overcrowded and created an

atmosphere which was not conducive for youth upbringing opening up avenues for social disorganization. It is not as if no positive aspects could be associated with the findings of [20] and [21], but their research was connected more to the negative influences of these plantations.

4.2.2 Education and training

Tea cultivation in NSD has contributed to formal and informal training. The location of the Cameroon Baptist Primary School (C.B.C) at Kakar, close to the plantation was a strategy to educate children of inhabitants and plantation workers. Many children have been trained in this institution. Such findings have much similarities with those of [20]. Given the fact that his research was, however, focused on plantation settlements, social disorganization and lumpen culture, in Fako Division, South West Region of Cameroon, he avowed that youths in these schools have a common character traits which could be summarized in early drop out from school, early introduction into sex life, with a consequent teenage pregnancy. Since the privatization of NTE, enrolment of pupils in this school has been reducing. Statistics from the school register shows that in the 2002/2003 academic school year, the number of people enrolled was 391. It has declined progressively to 241 in 2005/2006 school year and 142 in 2007/2008. This is because most workers lost their jobs and could not afford to pay school fees for their children. More so the government of Cameroon created a Government Primary School at Kakar which also accounted for the drop in the enrolment at CBC. In the informal sector, many people have been trained as workers in various domains to work in the plantation. Findings by [18] contradicts the current research as they discovered that most parents do not promote children's education as they attend school without didactic materials (exercise books and textbooks). For such parents, working in the plantations is the best option for their children.

4.2.3 Health services

The NTE health center is one of the first health service to be created in NSD. It was created to provide health care services to plantation workers and to the local population. Health services were offered at reduced prices and workers of the estate who did not have money were treated on borrowed basis. In 1997 about 7,842 patients were consulted yearly (CTE health center consultation records). In 2008 the number dropped significantly to about 70 patients. This drop is explained by the difficulties faced by villagers after privatization, corroborating the findings by [19] that the Cameroon Development Corporation has seemingly maintained a deplorable social responsibility record wherein farm labourers are the sacrificial lambs in the quest for increased economic output which is then proclaimed as "development".

Photo 1. Workers camp

Photo 2. Cameroon Baptist Convention School

4.2.4 Land tenure conflicts

Although the cultivation of tea has brought positive impact on the population of NSD, it has equally created more problems to the inhabitants. The creation of this estate in Ndu has contributed to an increase in the population of NSD. According to the results of the 1987 Population and Housing Census of Cameroon, NSD had a population of 61717 inhabitants. In 1995 the population increased to 86,008 and eventually rose to 106,233 inhabitants following the 2005 Population and Housing Census results conducted in Cameroon [22]. Today the population is projected to 131,524 inhabitants. With such an astronomical rate of population growth, the need of land for agriculture and other land uses has equally increased tremendously over time bringing about insecurity in tenure to land owned by CTE and some small holder tea farmers.

Land tenure disputes here range from land ownership conflicts between the CTE and the people, small holder schemes and the people, small holder schemes and the CTE and even within the small holder scheme themselves (Fig. 11). Villagers have encroached and are still encroaching into tea cultivated areas. The aspect of encroachment is very serious as it is common in all plantations of the CTE in Cameroon. In the CTE Ndu, encroachment is intense and glaring in the South Eastern part for building and in the Southern part for agriculture. It is manifested through the displacement of boundary pillars, farming within the estate`s land (Sassah), construction of houses (Baraki) and grazing of cattle and sheep by nomads (Photos 3 and 4).

4.3 Environmental Implications

For centuries, anthropogenic activities have been a trivial force in the environmental equation, but this changed dramatically in the 20th century, particularly in the last 50 years [23]. Encroachment most often is carried out by farmers who practice peasant agriculture through the use of unsound techniques which have often contributed to unwanted bush fires. This is supported by [24] who noted that agricultural land use (exploitation of natural landscapes for agricultural purposes) is the most pervasive of all land uses in the world today. This is because large amounts of natural vegetation (tropical forest/woodlands and savannas/grasses) have been cleared over the years for agricultural purposes in response to increasing population and the need to produce more food [25]. Bush fires are a great threat to the tea plantation and to the eucalyptus forest (Photos 5 and 6). To protect the forests and the tea plantation from bushfires, the management often do organize fire tracing at the start of the dry season so as to protect trees and tea plants in the event of bush fires. Fire guards are recruited in the dry season to monitor and report the occurrence any bush fire incident.

Photo 3. Land encroachment through farming   Photo 4. Pillar displaced by unsatisfied farmers
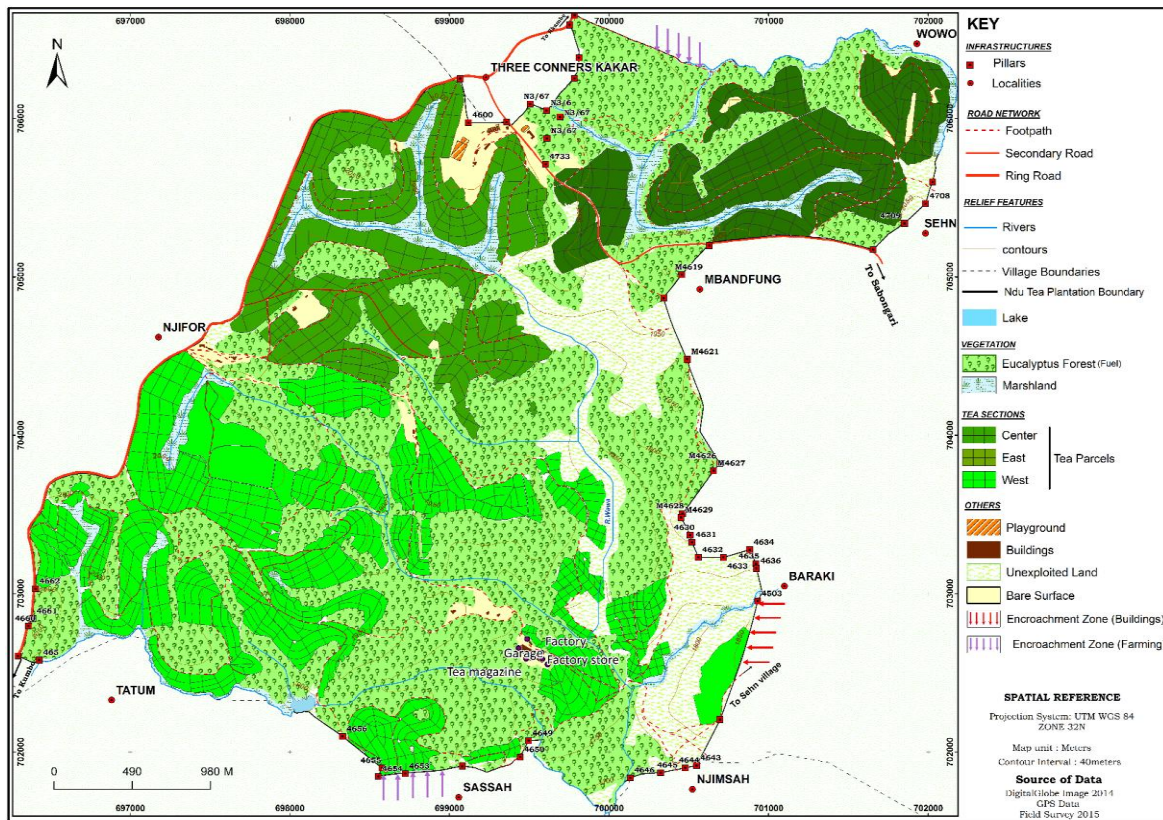
Fig. 11. Land tenure conflicts in Ndu Sub Division
Source: Digital Globe image 2018/field survey

Photo 5. Bush fire approaching the tea plantation

Photo 6. Eucalyptus forest consumed by bush fire

It is, however, important to note that land tenure conflicts in NSD existed even before the creation of the tea estate. However, these conflicts have been aggravated as a result of the introduction of tea cultivation in this sub-division. Conflicts have equally arise based on the quality of tea produced and the need of labour to work in the plantations. Small holders also need labour for their own plantations, though labour is more dependent on the family. Some villagers prefer to work as part time in the small holder farms in the CTE as it gives them ample time to carry out other activities. This has furthermore aggravated conflict between the CTE and small holder tea farmers. Other problems include environmental pollution through chemical spraying, fertilizers, and deforestation. [26] corroborated this current view and averred that the environmental impacts of plantation agriculture include but not limited to habitat fragmentation, degradation and loss of biodiversity. Such findings are consistent with those of [17] who noted that on the environmental front, unsustainable plantation growth is often accused of causing increased emissions of greenhouse gases (GHGs), loss of biodiversity, water cycle destabilization, soil erosion, nutrient loss as well as land and water pollution.

5. CONCLUSION

This paper had as objective to quantitatively analyse the spatio-temporal dynamics of LULCC patterns in Ndu Sub-Division (NSD) in a bid to un-earth the socio economic and environmental controversies that accompanied these dynamics so as to suggest escape routes to curtail the intriguing situation. Between 1988 to 2018, NDS experienced a drop in farmlands and savanna vegetation by 1.9 % (from 60882.7 to 58616.6ha) while forests, built-up areas, tea parcels and small holder schemes witnessed an increased by 1.1% (18109.7 to 18500.9ha), 39.7% (13184.4 to 3051.5ha), 5.2% (619.85 to 688.27ha) and 100% (0 to 73.2ha) respectively. These changes have brought positive and negative impact on the socio-economic development in NSD. On the positive side, about 1500 people are involved in tea cultivation and production as well as other tea related activities. This has brought an increase in household and council income, infrastructural developments, improvement in the living standards of tea workers and an increase in the number of people involved in the cultivation and sale of tea nationwide. On the negative side, tea cultivation has sparked up land tenure conflicts. Besides, environmental problems such as bush fires have surfaced as farmers try to increase the sizes of their farms. Other environmental issues include environmental pollution through chemical spraying, use of fertilizers and deforestation. Measures put in place by the management of Cameroon Tea Estates (CTE) to contain these problems are largely unsatisfactory as far as planning, monitoring towards securing and

solving land tenure disputes is concerned. It is for this reason that an appropriate tool is required for a proper planning, monitoring and evaluation of results to ensure effective management. Besides, appropriate zoning plans and land use maps should be produced to facilitate decision taking.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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