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The Last Twenty-One Years of Landscape Management in the Forest-Savannah Transition Zone: Case of Ngoro Municipality in Cameroon

Os Últimos Vinte e Um Anos de Gestão Paisagística na Zona de Transição Florestal Savânica: Caso do Município de Ngoro em Camarões

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Abstract

In recent decades, environmental challenges have increased with climate change, which is strongly linked to the pressure of human activities with a consequence on natural landscape change. Based on the forest-savannah transition zone of Cameroon, the aim of this study is to analyze the last twenty-one years management of the Ngoro municipality landscape by the government; and also, analyze the local people impact on these landscapes. The spatio-temporal dynamics of the Ngoro landscape was measured using two Landsat images (TM 2000 and OLI from 2021) downloaded free and analysed with ENVI software based to the supervised classification algorithm. The cartographic approach was combined with surveys conducted with 152 key informants through a questionnaire. Results revealed that, the natural forest cover has experienced a regressive dynamic over 21 years (2000–2021). Seven land cover classes were identified namely old forest, shrubland and grassland, bare soil/slash and burn areas, plantation/agroforestry systems, urban, water surface and croplands. Forests and savannah which are the natural landscape have decreased in the twenty-one years under study, at a rate of -165 ha/year and -525 ha/year respectively, while bare soil and slash and burn areas (+183 ha/year), and crop land (+229 ha/year) have increased. Concerning landscape management, in the twenty-one years under study, 8% of the area has been allocated as community forest. The remaining 92% that has not been allocated is managed by the community. The community established farms (44%), inherited their parents' farms (37%), bought land (10%) or received land as a gift (8%). The Ngoro municipality with its High Conservation Value potentials, harbours several endangered species, requires further empirical studies that can help identify biodiversity hotspots which will be beneficial for conservation. There is also the need to integrate indigenous Cameroonian initiatives that enhance sustainable landscape management practices.

Keywords: Vegetation dynamic; Land cover change; High Conservation Value

Resumo

Nas últimas décadas, os desafios ambientais aumentaram com a mudança climática, que está fortemente ligada à pressão das atividades humanas, com consequências na mudança da paisagem natural. Com base na zona de transição da floresta savânica de Camarões, o objetivo deste estudo é analisar a gestão dos últimos 21 anos da paisagem do município de Ngoro pelo governo e também analisar o impacto da população local nessas paisagens. A dinâmica espaço-temporal da paisagem de Ngoro foi medida usando duas imagens Landsat (TM 2000 e OLI de 2021) baixadas gratuitamente e analisadas com o software ENVI com base no algoritmo de classificação supervisionada. A abordagem cartográfica, foi combinada com pesquisas realizadas com 152 informantes-chave por meio de um questionário.

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Os resultados revelaram que a cobertura florestal natural passou por uma dinâmica regressiva ao longo de 21 anos (2000–2021). Foram identificadas sete classes de cobertura da terra, a saber, floresta antiga, arbustos e pastagens, solo descoberto/áreas de corte e queima, sistemas de plantação/agroflorestamento, urbano, superfície de água e terras agrícolas. As florestas savânicas, que são a paisagem natural, diminuíram nos vinte e um anos estudados, a uma taxa de -165 ha/ano e -525 ha/ano, respectivamente, enquanto o solo descoberto e as áreas de corte e queima (+183 ha/ano) e as terras de cultivo (+229 ha/ano) aumentaram. Com relação ao gerenciamento da paisagem, nos vinte e um anos estudados, 8% da área foi alocada como floresta comunitária. Os 92% restantes que não foram alocados são gerenciados pela comunidade. A comunidade estabeleceu fazendas (44%), herdou as fazendas de seus pais (37%), comprou terras (10%) ou recebeu terras de presente (8%). O município de Ngoro, com seus potenciais de Alto Valor de Conservação, que abriga várias espécies ameaçadas de extinção, requer mais estudos empíricos que possam ajudar a identificar os pontos críticos de biodiversidade que serão benéficos para a conservação. Há também a necessidade de integrar iniciativas indígenas de Camarões que aprimorem as práticas de gestão sustentável da paisagem.

Palavras-chave: Dinâmica da vegetação; Mudança na cobertura da terra; Alto valor de conservação

1 Introduction

Natural ecosystems are the sources of several goods and services (MEA 2005). They contribute ecologically to ecosystem biogeochemical functioning that include climate regulation, soil regulation, water purification and biodiversity conservation (Gouwakinnou et al. 2019; Lhoest et al. 2020). The changes in occupation and land use strongly and rapidly affect biogeochemical cycles at local, regional and even international scales (Barima et al. 2009; Adjonou et al. 2018). The impacts of natural landscape cover conversions on biodiversity, land degradation, and the capacity of biological systems to support human needs are a major concern worldwide (Dylan 2023). Anthropogenic disturbances that are mainly represented by the unsustainable exploitation of timber and Non-Timber Forest Products (NTFPs), the development of infrastructural activities, exposing the forest cover and large-scale agricultural activities are amongst the drivers of landscape change (Eva et al. 2010; Zekeng et al. 2019; Feudjio et al. 2023; Kenne et al. 2023). Humankind has a harmful effect on the environment, but in some cases, humanity becomes aware of her responsibilities and takes preventive actions to ensure the sustainable management of these landscapes (Egoh et al. 2012).

Landscape management is the care of land to ensure that it fulfils the needs and aspirations of mankind in an effective and sustainable manner for present and future generations. Landscape management strategies have emerged throughout the world to deliberately increase synergies and reduce trade-offs between rural livelihood development, agricultural production, and ecosystem conservation, through a variety of entry points (Scherr et al. 2014). Different approaches have been developed for landscape management assessment, with the spatial-temporal approach being the most recommended by several authors to understand the dynamics of land cover over time.

Agroforestry systems are one approach that contributes to ecosystem services maintenance and local peoples' wellbeing. This landscape management approach involves the conservation of some trees or introduction of others into landscapes made up of crops and/or livestock. Taking for example the case of the Ngoro municipality located in the Center region of Cameroon, it is an area where the main drivers of landscape degradation are the conversion of forests into agricultural lands and logging. According to Zekeng et al. (2019), increasing agricultural activities coupled with demographic pressures and infrastructural development are the factors of highest concern in the degradation of the natural landscape.

In recent decades, environmental challenges have increased with climate change. This is strongly linked to the pressure of human activities, thus the necessity to advocate for the conservation and maintenance of forest cover as a solution. In this vein, in 2019, "The Sustainable Trade Initiative" and "Worldwide Fund for Nature" commissioned some consultancy firms to carry out a socio-economic and environmental baseline study in the Ngoro municipality. The choice of this municipality stems from its status as a priority area given that it is part of a major cocoa production basin and also constitutes an area of conservation concern. PNDP (2021) found that, the Ngoro municipality's landscape has witnessed a serious transformation in recent years. Considering the importance of reassessing the cocoa sector's role on the international stage over the past twenty-one years, its effects on natural landscapes and the ecosystem services they offer, along with the demand for infrastructure development despite ongoing natural land loss, will be significant. Therefore, it remains unclear how the Ngoro municipality's future will unfold if the project continues to progress. Despite Cameroon's ratification of initiatives such as zero deforestation and biodiversity conservation, the question is whether past and present management is sustainable in terms of preserving natural landscapes and the ecosystem services they provide. In order to propose concrete solutions that are suitable with the management of the landscape, it is important to evaluate the past trends and dynamics of this landscape. Better understanding of

the causes and impacts of landscape degradation is critical to identifying their adverse effects on biological diversity and human development. This important information will set the pace as the main objective of this study which is to analyze the past twenty-one years of landscape management in the Ngoro municipality. It would therefore be a question of analyzing the spatial-temporal dynamics of the Ngoro municipality's landscape from 2000 to 2021; and local people impact on the natural landscape.

2 Methodology and Data

2.1 Study Area

This study was carried out in 2022 in the Municipality of Ngoro which is geographically situated between longitude 11°10 and 11°30 E and latitude 4°40 and 5°20 N. The municipality is found in the Mbam and Kim Division, Centre Region of Cameroon (Figure 1). Ngoro municipality covers a total area of 1576 km². Its altitude varies between 400 and 600 m with a relief that is not very uneven, characterized by plains and gentle slopes. The soil is characterized by a ferralitic texture and has affinities with brown soils where hydromorphic soils are found along the rivers. The climate of Ngoro municipality like the case in the Centre region of Cameroon is a sub-equatorial Guinean climate characterized by four seasons namely, a short rainy season (March to June), a short dry season (June to mid-August), a long rainy season (mid-August to October) and a long dry season (October to March). The average rainfall is around 1100 mm and the average annual temperature varies between 23°C to 27°C (PNDP, 2021). The municipality of Ngoro belongs to a forest-savannah transition zone with savannahs dominated by species such as *Pennisetum purpureum*, *Chromolaena odorata*, *Hyparhenya rufa*, *Mimosa* sp. and grasses as well as swamp areas dominated by Maranthaceae and Zinziberaceae (Letouzey 1985). Agriculture, which is mostly focused on cocoa, yam, cassava, banana, cocoyam, and others represents the main activities of local people in the Ngoro Municipality (PNDP, 2013; PNDP, 2021).

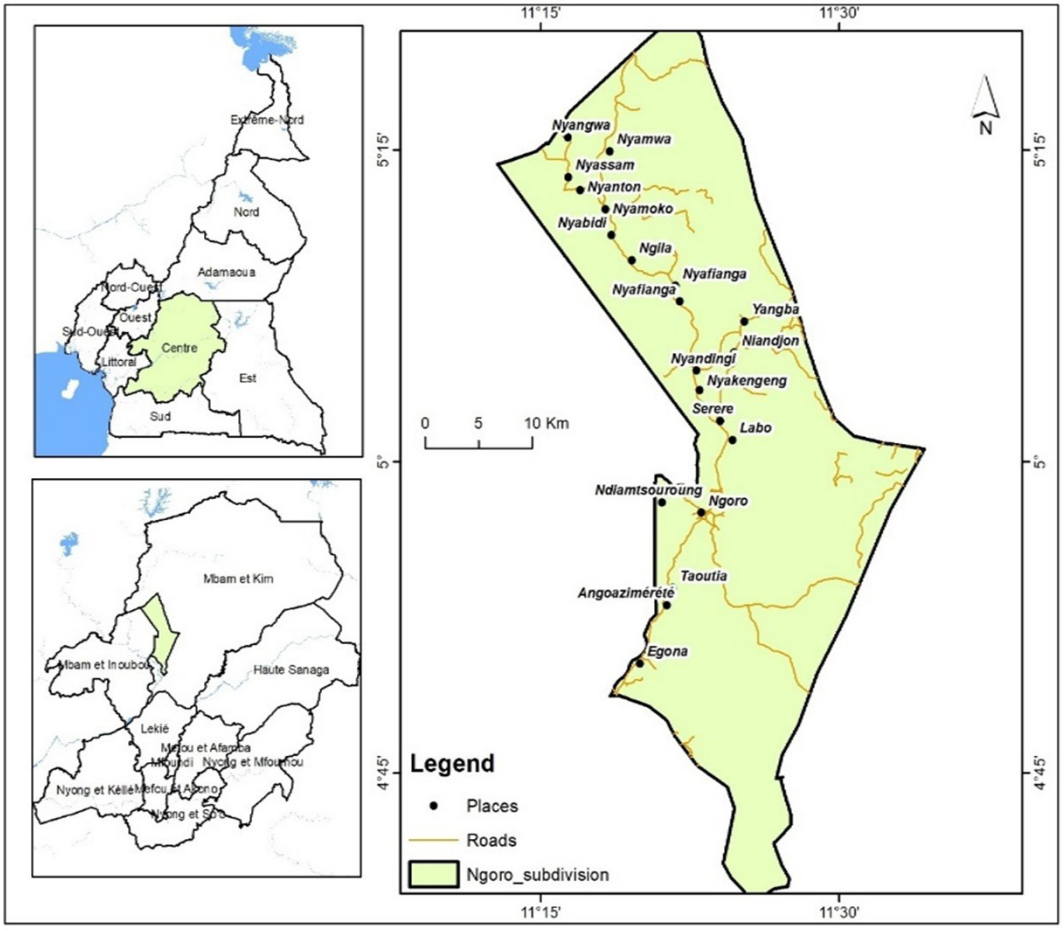

Figure 1 Localisation of Study area. Source: Forest Atlast for the year 2020. Projection System: WGS84, Zone 32N.

2.2 Data Collection

The Landsat satellite images used in this study were downloaded from the NASA website https://earthexplorer.usgs.gov/ in GEOTIFF format from the Thematic Mapper (TM) and Operation Land Images (OLI) sensors for the years; 2000 and 2021 respectively (Table 1). These images have a spatial resolution of 30 m and cover the dates 22 November 2000 and 27 December 2021 (period choose was based on seasonality and availability of best quality images). These dates were chosen in reference to the periods of post economic crisis marked by migratory movements of the population and habitat in this study area, as the evolution of this population is an important driver of land use change. All these images were acquired during the dry period (November to December), which is the best time to see plant communities in the tropics, but also the period when cloud cover is lowest (Barima et al. 2009; Kouassi 2014). In addition to these Landsat images, we used 1:200,000 scale topographic maps from the National Institute of Cartography (INC), as well as databases from the 2021 Forest Atlas to extract natural and physical elements that could help facilitate the photo interpretation of satellite images.

The Google Earth application of January 2021 was used to finalize and validate the land use maps for the study area. In addition to the spatio-temporal data collected, interviews were also conducted with stakeholders, as well as direct observations and GPS coordinates collected in the field which were all used for final validation of land use change in the area. Table 1 gives details of the characteristics of the images used.

Based on the fact that lands without legal or government statute (obtain near local administrative actors in charge of forest) in the study area are generally managed traditionally, we conducted interviews with key stakeholders notably administrative authorities in charge of agriculture (MINADER), forests (MINFOF), the Municipal Council of Ngoro, leaders of NGOs, traditional authorities and other stakeholders involved in cocoa activities in the area. Surveys using a questionnaire and focus group discussions were also carried out where 152 persons belonging to 12 villages were surveyed using the snowball principle to know how they did acquire and manged land.

The participatory mapping data was extracted from the topographic map of Ngoro Municipality and from discussions with local people in the target villages. The aim of the participatory mapping data collection was to locate on the base maps all the key environmental features, particularly the areas of High Conservation Value (HCV) in Ngoro municipality.

2.3 Data Analysis

Analysis of the spatio-temporal dynamics of land use was processed using ENVI 5.3 software. The processing was carried out in several stages. Pre-processing consisted of combining the layers into a single multispectral image using the "layer stacking" tool in order to extract the study area and improve the appearance of the images by calibrating on the frequency histogram of radiometric values (Donnay 2000).

After visual exploration of the image, the RGB colour composition using mid-infrared, near infrared and red, respectively, was used to highlight colour contrasts useful for the discretization of the different land cover classes (Coulibaly et al. 2016). The identification of land cover classes in the Ngoro commune was based on the guidelines of the Intergovernmental Panel on Climate Change (IPCC 2003), particularly the good practice guide, which recommends using similar works in the study area to better identify land cover classes. Chart 1 shows the land cover categories identified from the satellite imagery and their justifications.

The image classification method was based on the Maximum Likelihood algorithm, the most used for supervised classifications of multispectral images and for monitoring LUCC (Land Use and Land-Cover Change) (Rogan & Chen 2004). Based on the reflectance of pixels, this method calculates the probability of them belonging to a given class. The pixel was assigned to the class for which the probability is highest. However, if this probability does not reach the expected threshold, the pixel is classified as "unknown".

Table 1 Characteristics of the data used.

Type	Resolution	date	Source	Utility
Image Landsat TM	30 m	22th November 2000	USGS	Land use 2000
Image Landsat OLI-TIRS	30 m	27th December 2021	USGS	Land use 2021
Digital Globe	2.5 m	23th December 2021	Google earth pro	Validation of classified Landsat Image

Finally, a majority filter with a 3×3 window was applied to homogenise the cartographic renderings. The aim of this operation is to assign the central pixel of the filter to the most represented class. The confusion matrix was used to assess the accuracy of the classification results. Figure 2 illustrates more clearly the different stages in satellite image processing.

However, the cartographic layout was produced using ArcGIS 10.3 software and the static calculations were carried out using Excel 2021.

Chart 1 Land cover classes identified by photointerpretation from Landsat images.

Class of soil occupation	Description and Justification
Forest	Area dominated mainly by dense forest, patches of dense dry forest, patches of gallery forest.
Mosaic savannah Shrubs and trees	These are savannah formations dominated by herbaceous plants and shrubs, characterised by a low density of trees.
Bare soil and burnt area	These are areas stripped of vegetation and dotted with slash-and-burn and fallow land, which occupy large areas in a discontinuous fashion.
Plantations	Area dominated by agroforestry crops (cocoa, oil palm and plantain).
Built-up areas	Areas dominated by urbanised dwellings, roads and artificially covered surfaces that occupy discontinuous areas of land.
Water surface	Natural or artificial watercourses and bodies of water.
Field of crops	An area dominated by semi-permanent arable fields cultivated in associations.

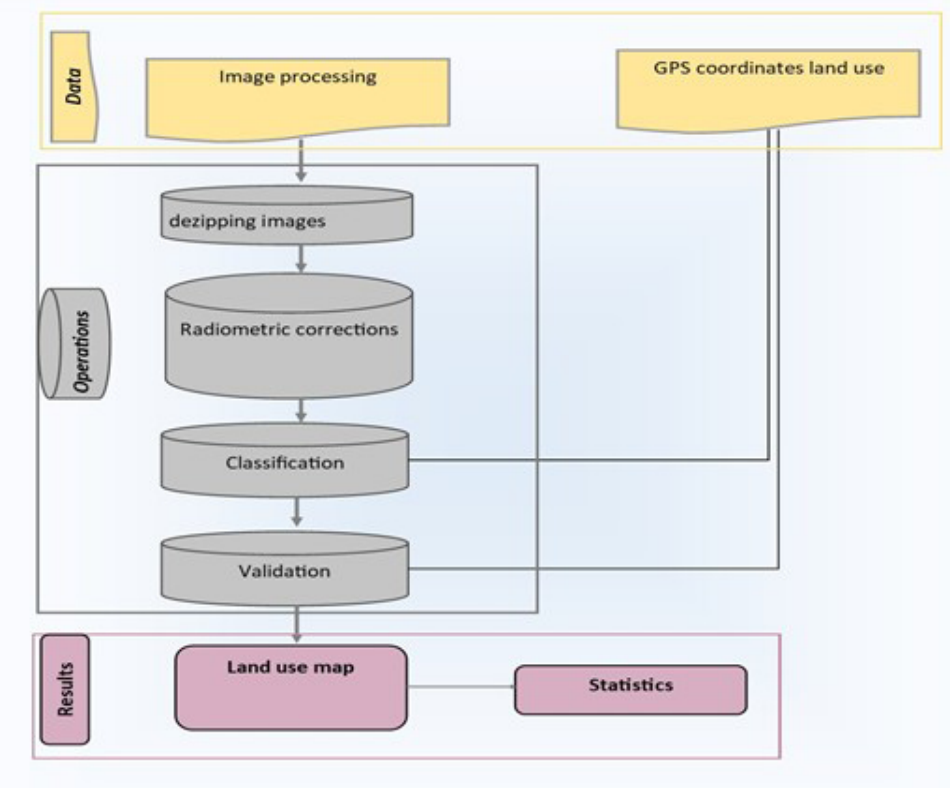

Figure 2 Summary diagram of satellite image processing.

In order to highlight the dynamics of each land cover category, the average annual rate of spatial expansion was calculated. This expresses the proportion of each land cover category that changes annually based on the surface area of these categories. The average annual rate of spatial expansion was calculated using the formula of Bernier (1992) (Equation 1).

$$T = [(\ln S2 - \ln S1) / ((t2 - t1) \times \ln e)] \times 100 \quad (1)$$

S1 and S2: Area of a landscape unit at date t1 and t2 respectively.
t2 - t1 : Number of years of evolution (21 years) ;
ln: Napierian logarithm.
e: Basis for the natural logarithm (e = 2.71828).

Negative values indicate an annual regression, while positive values indicate an annual expansion.

The calculation of the deforestation rate between the periods 2001-2021 was determined using the equation proposed by Puyravaud et al. (2002). As the study area does not overlap several Landsat image scenes, this formula was adopted to calculate the annual deforestation rate. It is presented by the following relationship (Equation 2).

$$\varnothing = -\frac{1}{t2 - t1} \ln\left(\frac{A2}{A1}\right) \quad (2)$$

We consider:

∅: Annual deforestation rate over the period between t1 and t2 in [%].
A1: Forest area in year t1; A2: Forest area in year t2
t1 date in year 1 and t2 date in year 2.

3 Results

3.1 Spatial Distribution of Land Cover Identified Over the Twenty-One Years in Ngoro Municipality

The land cover analysis resulting from the processing of Landsat satellite images of Ngoro municipality between 2000 and 2021 permitted the identification of seven land cover types, namely, forest, shrubland and grassland, bare soil and slash and burn area, plantation/ agroforestry systems, urban, water surface and cropland. Figure 3 shows the spatial distribution of land use in the Ngoro Municipality landscape between 2000 and 2021.

3.2 Land Cover Change Over the Twenty-One Years in Ngoro Municipality

The analysis indicates that in the year 2000, the landscape physiognomy of Ngoro Municipality was largely dominated by vegetation formations; notably forests (56.45%), wooded and grassy savannah (23.22%). However, anthropogenic units such as crop fields and fallow lands, plantations (Agroforestry based on cocoa, oil palm and plantain), bare soils and slash and burn areas, and built-up areas occupied respectively 10.38%, 5.73%, 3.39% and 0.81% of the total area of the Municipality. Water bodies occupied about 0.03% of the landscape. Twenty-one years later (in the year 2021), the land-use situation of the Ngoro Municipality landscape appears to be less and less forested (Table 2). However, there is still a predominance of forest-type vegetation formations. The forest class for this period occupied 53.50% of the total area of the landscape, corresponding to an area of 62,873.1 ha. At the same time, anthropogenic units (plantations/agroforestry systems, crop fields and fallows, bare soil, and burned areas) became increasingly visible and occupied 14.47%, 10.27%, and 6.66% of the spatial entities respectively. Built-up areas (1.16%) and water bodies (0.10%) increased slightly, although their proportion was less than 2%.

Out of 66337 hectares of forest in 2000, 3463.9 hectares were deforested between 2000 and 2021, which represents a deforestation rate of 0.26%. Indeed, about 3% of the forest cover has disappeared in twenty-one years.

3.3 Transition Matrix of Land Use Change Over the Twenty-One Years

Table 3 presents the transition matrix of land use change between 2000 and 2021. The diagonals of each matrix indicate the proportion of land use classes that showed persistence between 2000 and 2021. The off-diagonal entries represent land uses that showed transitions from one class to other classes during the period 2000-2021.

During the period 2000 and 2021, the forest remained untouched (6069.31 ha), it was converted into tree and shrub savannahs of 34.51 ha and also converted into bare soil and burnt area of about 46.36 ha. It has also been converted into Agroforestry plantations of 594.92 ha. These forests were also converted into fallow fields, settlement, and water bodies of 599.86 ha, 8.03 ha, and 6.53 ha respectively. During this period the loss of forest is thus estimated at 731008.69 ha.

On the other hand, the tree and grass savannah class remained intact by about 1458.96ha. It converts into forest of about 380.63 ha, into bare soil of 502.21 ha,

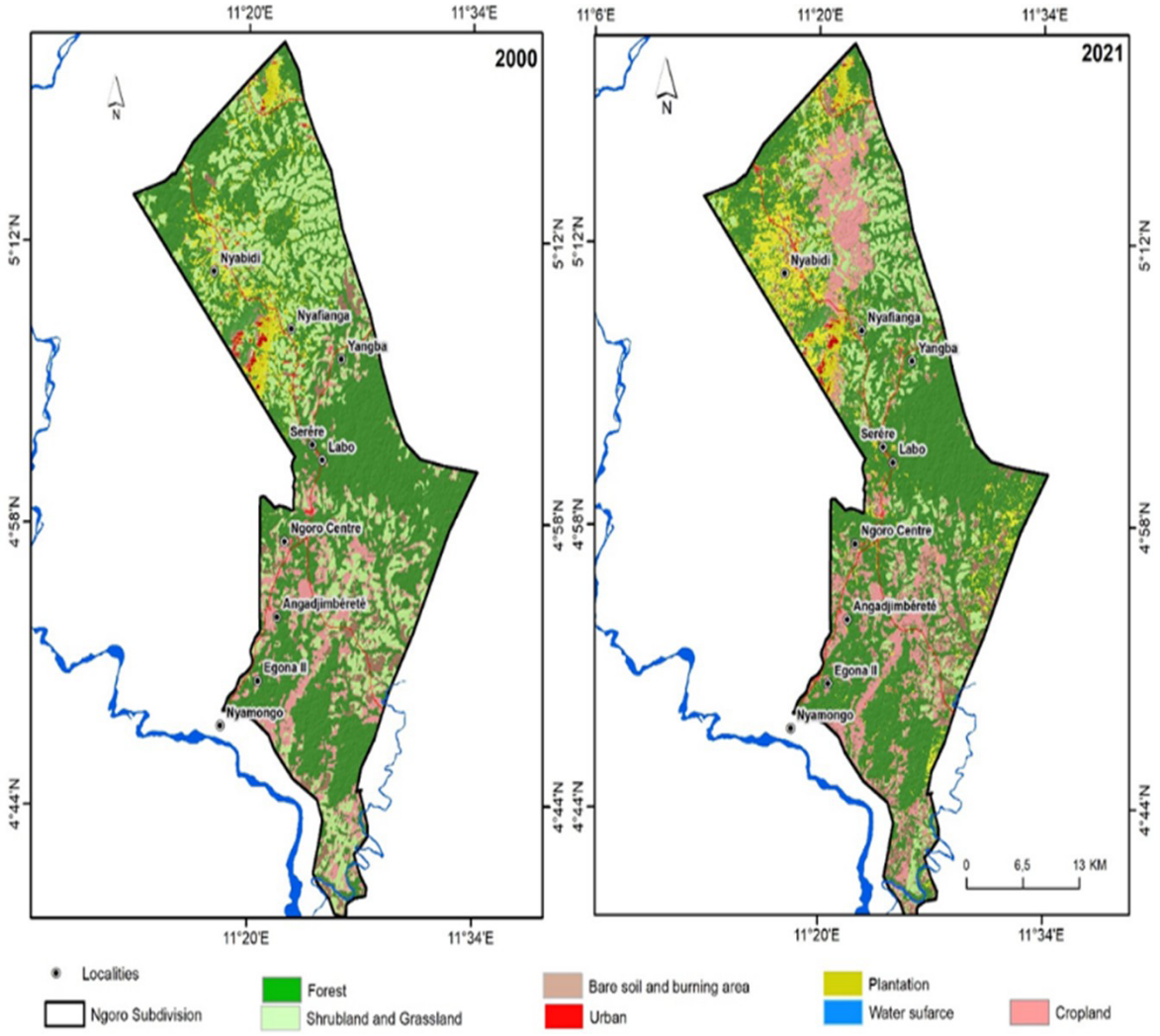

Figure 3 Land use change over the last twenty-one years (between 2000 and 2021) in Ngoro Municipality.

Table 2 Land use statistics in Ngoro Municipality over the twenty-one years period (2000-2021).

Class name	Area (Ha) 2000	%	Area (Ha) 2021	%	Annual change%	Global Change (%)
Forest	66337	56.45	62873.1	53.5	-0.26	-5.36
Shrubland and Grassland	27289.2	23.22	16264.9	13.84	-2.46	-51.75
Bare soil and slash and burn area	3980.34	3.39	7821.99	6.66	3.22	67.56
Plantation	6728.94	5.73	12073.9	10.27	2.78	58.46
Urban	954.09	0.81	1367.53	1.16	1.71	36.00
Water surface	37.53	0.03	115.38	0.1	5.35	112.31
Cropland	12197.6	10.38	17007.9	14.47	1.58	33.24
Total	117524.7	100	117524.7	100		

Table 3 Transition matrix of land use change between 2000 and 2021. F= Forest, SG= Shrubland and Grassland; BBA= Bare soil and slash and burn area; PT=Plantation; Ub= Urban; WS=Water surface; CPL= Cropland

Final date 2021	Initial date 2000							
	F	SG	BBA	PT	Ub	WS	CPL	Total
F	6069.3	380.6	38.2	204.1	11.3	0.7	290.3	6994.6
SG	34.5	1459.0	163.2	6.1	7.3	0.03	139.7	1809.8
BBA	46.4	502.2	111.5	7.4	13.4	0.2	188.3	869.4
PT	594.9	237.8	13.5	411.7	22.0	0	63.6	1343.4
Ub	8.0	25.0	5.3	19.8	45.8	0	12.8	116.7
WS	6.5	0.6	2.2	0	0	3.2	0.3	12.8
CPL	599.9	423.6	106.9	97.7	6.2	0.1	658.9	1893.2
Total	7359.5	3028.8	440.8	746.8	105.9	4.2	1353.9	13039.8

into plantation of 237.75 ha and finally into built-up area of 24.95 ha. The bare soil and slash and burn area class remained intact at about 111.48 ha and was transformed into wooded and grassy savannah at 163.24 ha. It was also transformed into forest of about 38.23 ha, plantation of 13.49 ha, built-up area of 5.29 ha and cultivated area of 44226 ha. As for the plantations, they remained intact for 411.66 ha and were transformed into grassy and shrubby savannah for 6.05 ha. The water surfaces remained intact for 3.19 ha and were transformed into fields for 0.08 ha, bare soil for 0.15 ha and forest for 0.72 ha. 658.89 ha of crop fields remained intact and were transformed into tree and shrub savannah 188.34 ha and 186.3 ha, forest 290.3 ha, plantation 63.58 ha, bare soil and burnt area and water bodies 63.58 ha, 0.27 ha, respectively and finally to only 12.82 ha in the built-up area.

3.4 Landscape management over the twenty-one years

The landscape of Ngoro municipality was the subject of several management. At the level of the government. over the last twenty-one years, 12772 ha of the study area was assigned as community forest (3 in total) and for which their landscape that are considered like a non-permanent forest was managed by local communities through a simple management plan approved by the ministry in charge of forestry and wildlife in Cameroon. This represents 8 % of the total Ngoro municipality. This means that 144828 ha (92%), was not assigned to any legal or statutory landscape management.

FGDs and interviews with stakeholders led to the understanding that, non-assigned landscapes in Ngoro municipality have a customary hierarchy management consisting of a paramount chief. This is the first-degree chief residing in the Ngoro centre. Each of the 24 villages in the municipality of Ngoro is headed by a third-class chief who is responsible to the paramount chief (first-class chief) of the Ngoro centre. These chiefs manage the landscapes around their villages. Based on surveys done with local people, results showed that non assigned land of Ngoro municipality belongs to indigenous people and particularly to the first occupant. For each delimited village, over the last twenty-one years (2000-2021), many indigenous farmers created their farms by themselves (44%, land belong to first indigenous occupant), followed by those who inherited their parents' farms (37%), those who bought the land (10%) and those who received land as gifts (8%). Meanwhile, just 1% represented those who received land based on mutual arrangements, for example on agreement that the number of cocoa bags harvested per season is shared in an agreed ratio, or the land or farm has an amount that the renter pays to the land or farm owner per season.

On the other hand, agriculture was the principal driver of deforestation and forest degradation in Ngoro municipality as cited by 65% of those surveyed; followed by wanton wood harvesting (25%) and then wildfires (10%).

4 Discussion

4.1 Causes of Natural Landscape Change Over the Past Twenty-One Years in the Ngoro Municipality

The Ngoro municipality belong to the forest-savannah transition zone with a landscape made up predominantly of vegetation mosaics like forest and savannah. However, these landscapes have known a high spatial-temporal dynamic over the past twenty-one years. In fact, this study area has

undergone significant anthropogenic influence with an explicit and direct impact on forest cover degradation (Pfaff et al. 2009; Tra Bi 2013; Kenne et al. 2023). These landscape changes stem from the complex interactions between social, economic, political, cultural and technological processes (Feudjio et al. 2023). The conversion of forests to other land uses is driven by a number of factors, including climate and human activities, notably urban growth, population growth and the intensification of agricultural activities, which result in the transformation of large areas of forest, mostly into crop fields (Anonymous 2023).

Based on the direct drivers of Ngoro municipality landscape dynamic over the last twenty-one years, previous studies and findings from interviews with institutions, communities, NGOs and field observations, indicate that deforestation and forest degradation in the Municipality of Ngoro is historically linked to agriculture and in particular to the expansion of crops, notably cocoa. Subsistence agriculture has been identified as a major driver of deforestation and degradation (Ngono et al. 2015; Ndo et al. 2023). Small-scale producers are the main agents driving deforestation and landscape degradation. The MINEPDED (2017) report notes that conversions of less than one ha represent almost 65% of conversions and those between 1 and 2 ha are 15%. Ngoro municipality is the place 'par excellence' to produce cash crops such as cocoa, as cocoa cultivation represents the main activity for local people (Ngono et al. 2015; PNDP 2021). This area offers a set of elements that attract people in search of cultivable land (Anonymous 2023). With a strong increase in demand for cocoa beans, associated with attractive prices, cocoa farmers extend their cocoa-growing area by an average of 2 ha/year both in forest and savannah (Anonymous 2023), representing approximately 20 ha per cocoa farmer over the last twenty-one years, making it a significant driver of natural landscape degradation. Today, human wealth is measured in terms of the number of plots of land, or the surface area owned. New plantations are being opened under the impetus of city dwellers who appropriate the plantations to ensure a complementary income, a pension, or a land base.

Cocoa cultivation is done through the slash-and-burn technique which consists of felling trees on a forest plot and then burning the vegetation on it. This technique makes it possible to take advantage of the fertility of the soil acquired through humus, as the slash-and-burn process allows the organic matter to be mineralized and made rapidly available for crops. However, after the trees have been cut down, the fertility is only maintained for a short period, making it necessary to clear new plots, hence the shifting nature of this practice. Besides cocoa cultivation, others crop cultivation like cassava and oil palm have evolved from a subsistence crop to a commercial crop over the last twenty-one years, leading to degradation and deforestation of important natural landscape areas as well.

The study shows a more recent impact of fires on forest areas, which can have different origins. Similarly, artisanal timber exploitation is currently of great importance. Although it is not a major cause of deforestation, it leads to significant degradation of the forest cover, weakening its functioning and the ecosystem services it can provide by removing indigenous or even endemic species that structure forest environments. In addition, it can make the forest cover more vulnerable to fire or extreme weather events.

An indirect cause of deforestation and forest degradation is one that is part of the underlying process leading to actions that affect the landscape (Feudjio et al. 2023). Indirect causes of deforestation in the Ngoro zone include the demand for food, water, and shelter. These include market demand, urban growth linked to infrastructural development, demographic pressure and economic crisis coupled with internal migration waves that contribute to deforestation which have resulted in the transformation of vast forest areas into other land uses. The high rate of human population growth is increasing pressure on natural resources, especially forest resources. The main drivers of deforestation are slash-and-burn agriculture and the cutting of wood for fuel and export. In addition, there is the conquest of new land as a result of the internal migratory movements that have marked the Mbam and Kim division (Anglophone crisis, Boko Haram war in the far north of the country). In addition to migratory movements, is the increasing trend of livestock farming.

4.2 Future Threats and Future Trends of Natural Landscapes Change in Ngoro Municipality

According to previous results found, the future evolution of deforestation in the Municipality of Ngoro shows an increase in agricultural areas especially cocoa cultivation by using slash and burn techniques, also an increase in the exploitation of illegal timber for lumber as a result of the financial attraction of building houses, and finally an increase in the use of fires in forest areas than in savannah areas. Concerning the future evolution of deforestation, observations suggest that pressure on the forest will be maintained or even increase, continuing the recent dynamics observed through the analysis of satellite images between 2000 and 2021.

In the same vein, according to interviews with administrative authorities, other projects/programmes are being developed at national, regional and local levels, which may have a beneficial or negative effect on deforestation

in the Ngoro municipality. Between these projects, we can cite, the project to open up the localities of the Municipality and the programme for the improvement of MINADER's flagship crops, notably cocoa and banana plantain. Following these observations, deforestation/degradation will increase in the Municipality of Ngoro.

4.3 Involvement of Ngoro Municipality in Sustainable Landscape Management

The implementation of sustainable management implies the identification of potential resources and threat, which help in the identification of measures that are adapted to the context. In this vein, a conceptual model to increase inclusive stakeholder participation and sustainability in local land use planning is required (Ewane et al. 2021).

The threats to wildlife are multiple, which constitutes a real obstacle to conservation efforts and the protection of biodiversity in general. Faced with this situation, the government has set up several mitigation instruments at the national level and has signed several conventions on biodiversity protection. The municipality of Ngoro have a high potential in terms of landscape diversity. According to PNDP (2021), there are numerous threatened species identified in the Ngoro municipality that include; *Gorilla gorilla and Manis tricuspis* that are critically endangered according to the red list of the IUCN. Vulnerable plant species like; *Milicia excelsa*, *Entandrophragma cylindricum, Diopyros crassiflora* and *Baillonella toxisperma* were identified, which are mainly species exploited either by logging companies or by artisanal sawmills.

Figure 4 shows the different High Conservation Value (HCV) zones identified in a participatory manner with

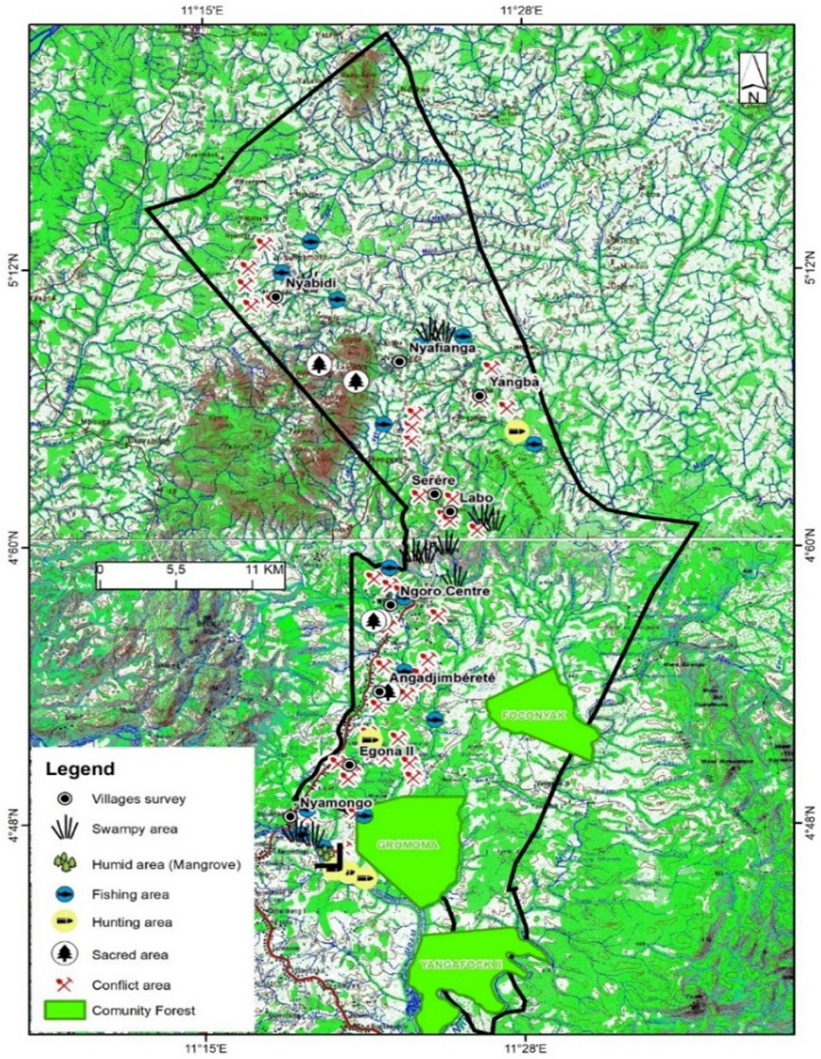

Figure 4 High conservation value areas in the landscape of Ngoro.

the support of the communities based on a topographic map of the municipality of Ngoro. The participatory mapping led to the identification of 03 categories of HCVs modelled after the generic guide for good practices in identifying HCVs proposed by Proforest (2020). These include HCV 5, which corresponds to Community Needs; HCV 6, Cultural Values; and HCV 3, Ecosystems and Habitats.

Type 5 HCV: Community Needs.

Type 5 HCVs include established community needs around which hunting, gathering, fishing, and NTFP collection areas that provide NTFPs to people on a seasonal basis are conducted. These areas are found extensively in the southern and northern parts of Ngoro municipality, including Nyamongo village, Ngoro centre and Nyabidi.

HCV type 6: Cultural elements.

Type 6 HCVs include archaeological sites that are recognized as being of national or international importance. In the study area, HCV 6 are limited to sites of cultural interest to the riparian communities and constitute sacred zones for them. These zones are very present in the northern and central parts of the municipality of Ngoro. These sites of cultural value have been identified in villages such as Ngoro centre, Nyabidi and Nyafianga.

HVC type 3 Ecosystem and habitats.

HCV 3 targets sensitive habitats: refuge areas, mangroves, sub-montane and montane forests, inselbergs and swamps, provided they are rare or potentially threatened. In the study area, HCV 3 is limited to wetlands, especially swamps and mangroves. These areas develop much more in areas of reliable altitude marked by abundant water and offer various services to the community, including the supply of NTFPs. These habitats were identified around the banks of rivers in villages such as Nyamongo and Ngoro centre of Ngoro municipality.

With the potential of threated species and the HCV potential, concrete measures or solutions in terms of landscape management are addressed to different stakeholders at different levels. For example, to maintain the potential of Ngoro municipality in terms of biodiversity and HCV, the government can create permanent forest, communal forest and FMUs not found in the Ngoro municipality. This is because the management plan of these approaches allows for sustainable landscape management. Also, some initiatives like cocoa with zero deforestation need to be applied considering the direct correlation between the expansion of cocoa cultivation and natural landscape degradation. With this, community stakeholders will be involved in local sensitization campaigns. It is important for all stakeholders to participate in the management of the landscape, given that the government is trying its best to accompany them through local governance frameworks.

5 Conclusion

By using satellites image analysis and information collected from stakeholders, this study enables us to analyze the landscape dynamics of Ngoro municipality that have occurred over the past years (between 2000 and 2021). From the seven-land covers identified, Ngoro municipality has witnessed enormous changes. Natural landscapes like forest and savannah have been decreasing in terms of their area while agricultural lands have been expanding. Cocoa cultivation represents the main occupation of local people that obtain their land through different ways. Moreover, this area attracts many agricultural investors, given that the Ngoro landscape is rich and has high levels of soil fertility. Nevertheless, with the deforestation rate estimated at 0.26% in the Ngoro municipality due to the high proportion of non-assigned landscape management which favors land appropriation by local people for agriculture Decision makers therefore need to encourage the allocation of some areas as permanent forests while strengthening the current landscape management and monitoring policies to ensure alignment with national and international sustainability standards notably those Cameroon has ratified.

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