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Analysis of the Spatio-Temporal Dynamics of Land Use in the Bamboutos Mountains of the West Region of Cameroon

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Abstract

The current level of knowledge of the biophysical situation, human activity and governance in the Bamboutos Mountains does not shed enough light on the dynamics of the vegetation, the socio-economic aspects and ecological opportunities that are essential for a successful restoration initiative in this degraded landscape of the Bamboutos mountain ecosystems. The objective of the study was to map and analyze the dynamics of land use from Landsat images of 1980, 2000 and 2021. Supervised classification by maximum likelihood was applied and the dynamics were analyzed using area curves and calculations. The cartographic results were used to produce land use maps. The analysis of the land cover dynamics shows that the evolutionary trend of the vegetation formations is essentially regressive for agro-forests and dense forests at −21.20% and −3.62% respectively. The classes that showed a clear progression were bare soil (9.78%), crop land (8.03%), built-up areas (5.19%) and shrubby savannahs and grassland (1.84%). Agriculture, livestock grazing and demographic pressure are the main causes of land degradation and mutation of the landscape. The results of this study provide an understanding of the land-use history of this landscape, and a solid basis for planning a restoration initiative. They provide guidance on priority areas and types of restoration intervention from a social, economic and ecological perspective.

Keywords

Bamboutos Mountains, GIS, Mapping, Degradation, Landscape, Restoration

1. Introduction

The Bamboutos Mountains landscapes located in the agro-ecological zone of the

Western Highlands constitute precious natural potential conditioning the survival of many human communities because of their stakes as the water tower of the west region of Cameroon, climatic regulator of this region, the site of great biological richness with multiple socio-cultural and economic virtues, the site with enormous tourism potential, food hoop for many Cameroonians and Central African cities (Ngoufo, 2014). According to Messinger & Winterbottom (2016), this ecosystem, like those of the Western highlands, is subject to severe montane forest degradation and exacerbated by climate change and poor agricultural land management techniques.

In the past decade, the town of Mbouda in the Bamboutos Highlands has been experiencing an unprecedented water crisis (Yemmafouo et al., 2009). As time goes by, the phenomenon continues to grow, to the point of worrying the collective conscience. The populations of this city have quickly set their sights on Cameroon water, which is responsible for supplying Cameroonian cities with drinking water (Ngoufo, 2014). However, Cameroon water, which is at the centre of all the controversies, is experiencing a deep-seated problem in Mbouda, as in many other Cameroonian towns: the gradual reduction in the quantity and quality of water in the catchment areas. Pioneering studies on this subject (Yemmafouo et al., 2009; Matsaguim et al., 2019; Fogaing & Tsalefac, 2020) showed that water scarcity in Mbouda is exacerbated by changes in land use in recent years in the Tsedeng catchment area of the Bamboutos Mountains, upstream of the dam. The area of permanent vegetation has decreased by 36% and the area of bare soil has increased by 66% between 1988 and 2007 (Yemmafouo et al., 2009). The current urgency of a multi-stakeholder intervention in this area stems from the fact that for several decades, numerous human actions have been erected at a dizzying pace to weaken this potential (Ngoufo, 2014). The human and ecological risks involved are multiple.

In view of this situation, it is important to carry out specific studies that will provide a sustainable basis for the successful restoration of these landscapes. Remote sensing and mapping offer an immense source of data to study. The spatial and temporal dynamics of environmental parameters can provide timely synoptic information for the identification and monitoring of local territories (Smith, 2012). In addition, they play a vital role in applications such as environmental damage assessment, land use monitoring, urban planning, as well as soil and crop yield assessment (Avakoudjo et al., 2014). The objective of this study is to assess land use changes in the Bamboutos Mountains based on mapping data of the locality. It is based on the hypothesis that the expansion of crop farms in the area combined with the effects of unsustainable management practices intervenes in the spatio-temporal dynamics of the landscape.

2. Methodology

2.1. Description of the Study Area

The Bamboutos Mountains landscape is located in the Western Highlands of Cameroon, between 5˚25' and 5˚45' North latitude and between 10˚00' and 10˚15'

East longitude (Leumbe et al., 2005). It constitutes a huge volcanic shield culminating at 2740 m above sea level as shown in **Figure 1** below.

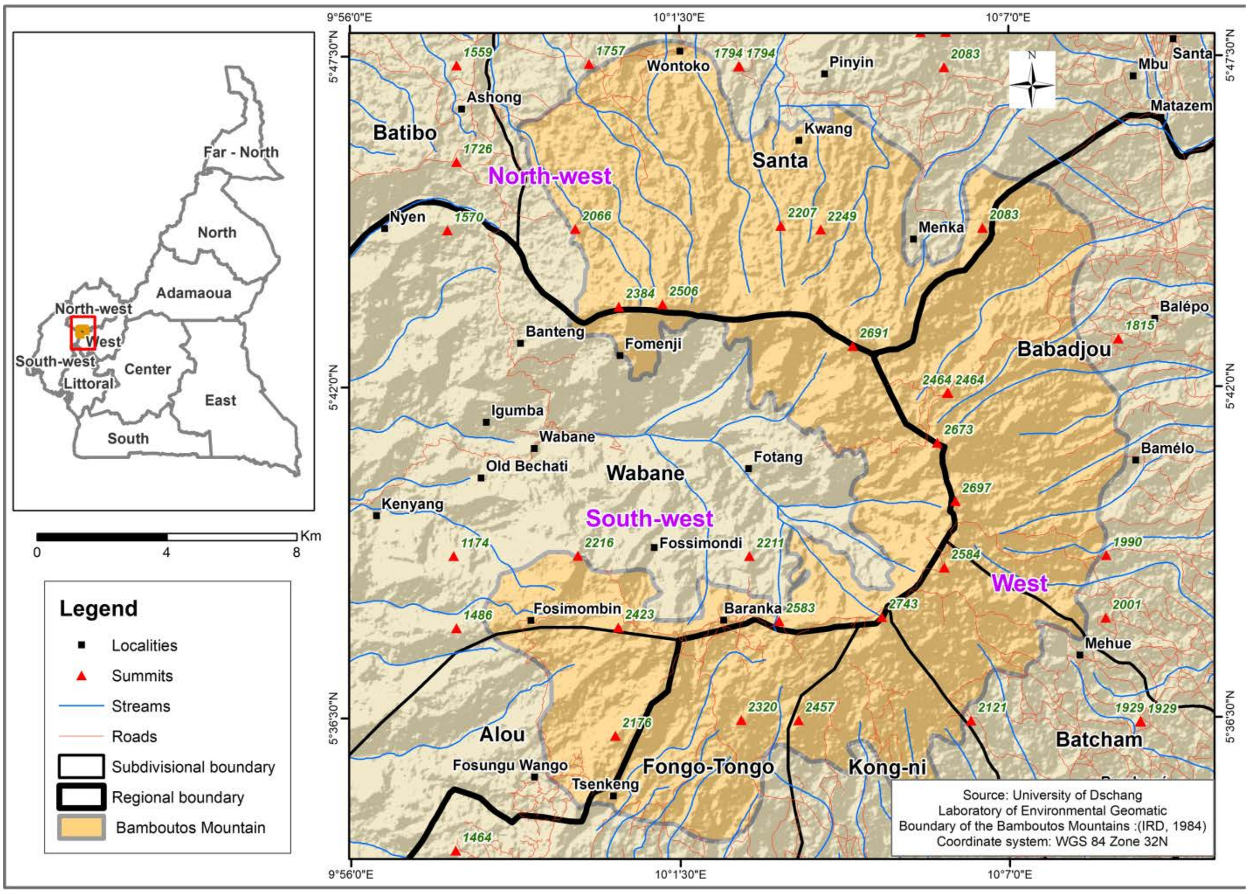

Figure 1. Location of the Bamboutos Mountains.

The communities that exploit the slopes of the Bamboutos Mountains are spread over 3 regions (West, North-West and South-West), 4 divisions (Bamboutos, Menoua, Mezam and Lebialem), and 7 subdivisions (Babadjou, Batcham, Nkong-Ni, Fongo-Tongo, Santa, Alou and Wabane) with 30 villages.

2.2. Village Sampling

Within a 5 km area of influence of the Bamboutos Mountains, 30 villages were identified, using the open street map 2019 platform, which provides a spatial data set of the world's landmass. They are presented in **Figure 2**.

Indeed, the choice of villages is based on the potential influence that these populations may have on the Mountain ecosystem, due to their proximity and accessibility. Thus, on the basis of the spatial stratification established from the boundaries of the Bamboutos Mountains, according to a zone of influence of 5 km, 33% which represented 10 villages were selected for data collection. This gradation is based on the assumption that the closer a community is to the Mountains, the more interactions it has with the landscape. Also, taking into account the reasons for insecurity in the North West and South West regions, only

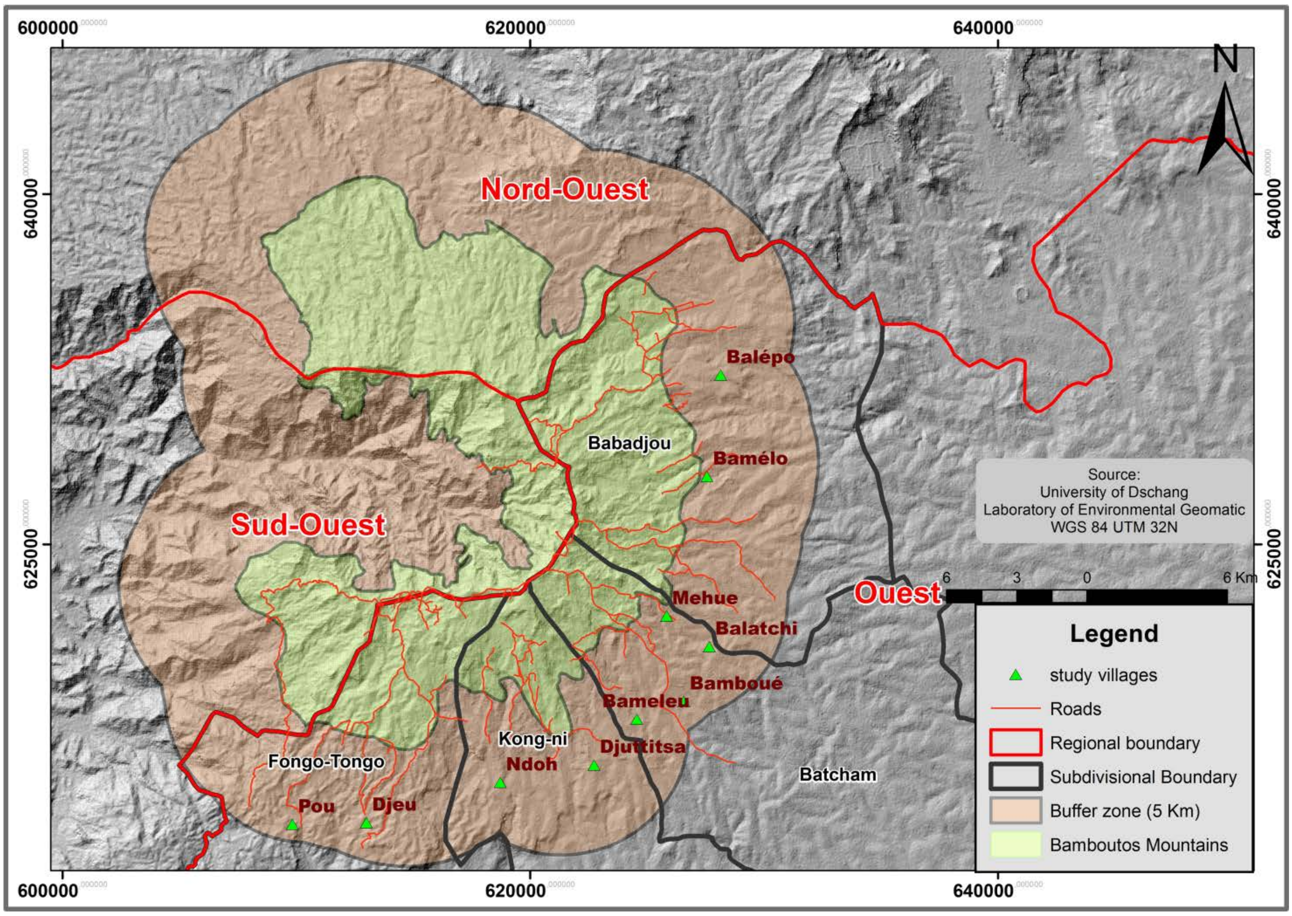

Figure 2. Sample map of study villages.

communities located in the districts of the Western region were selected.

2.3. Data Collection

Landsat satellite images from 1980, 2000 and 2021 were uploaded from the website https://earthexplorer.usgs.gov/ platform into GEOTIF format using Path 184 and Row 057. The Digital Globe image of 2021 was used for the finalization of the land cover map. The final validation of the different land cover maps was done using the pixel confusion matrix and data from field observations with a Global Positioning System (GPS) handheld receiver to locate the different land cover units. A camera was also used to film important sites (dense forest, agro-forest, crop fields, shrub savannah, etc). A data collection sheet was used to record all the information useful for the evaluation of the different changes.

10 Focus Group Discussions were organized in the 10 selected communities, i.e., 1 per community with 4 participants per exchange for the categorization of the drivers of deforestation and landscape degradation.

2.4. Data Analysis

2.4.1. Image Processing

Satellite image processing was carried out in two stages: image pre-processing and image classification. All processing was carried out using ENVI 5.3 mapping software.

Image pre-processing

This phase is the set of techniques (radiometric improvements and geographical recalibrations) aiming at standardizing the data format to allow their comparison at different dates. It was carried out in several stages, namely:

- **Unzipping and importing image strips:** this operation allows the extraction of the downloaded file into several image strips in order to exploit the information contained in each strip.
- **Combining bands:** in order to obtain a single multi-spectral image. Landsat images are made up of several bands. All bands were combined to obtain a master file containing all the information to be highlighted in the study area.
- **Radiometric corrections:** in order to improve their appearance and facilitate the interpretation and visual analysis of the scenes, the contrast between the different elements of the images was improved by playing on the dynamics of the radiometric values in the frequency histogram. The geometric improvements were not necessary because the images obtained had already been geometrically corrected on the basis of the UTM WGS 84 zone 32N projection. However, the other complementary map data (administrative boundaries, GPS data, hydrographic data and communication routes) were all projected UTM WGS 84 zone 32N.
- **Colour compositions:** colour compositions were made to associate three of the spectral bands of the image with display colours (red, green, blue). A colour composition associating the Near Infrared (NIR) band with the red colour, the Red (R) band with the green colour and the Green (G) band with the blue colour was carried out for the 1980 and 2000 image scenes, which constituted a composition known as (5-4-3). For the image scene 2021, the composition (6-5-3) was made. They are effective for analysing the vegetation.
- **Extraction of the study area**: This was done from the multi-spectral images obtained, following the boundaries of the Bamboutos Mountains proposed by the IRD in 1984.

Image classification

The second stage of the analysis consisted of a classification to obtain, for each date, the land use map. The knowledge of the study area guided the choice in favour of unsupervised and supervised classification, which made it possible to define the nomenclature of the different land use classes (dense forest, crop fields, savannahs, bare soil and others). The unsupervised classification was done in a preliminary way in order to get an idea of the distribution of the different land cover classes. It served as a preliminary map for the validation of the land cover units. The supervised classification was then carried out in order to identify the different confusion errors of the class pixels and to establish the final maps. The Maximum Likelihood algorithm was chosen for the supervised classification of the images, followed by the delineation of the training plots. This method calculates the probability of a pixel belonging to a given class rather than another. Pixels were assigned to the class with the highest probability.

Post classification and validation

After the image classification, the post classification was done. This consists of the validation of the treatments from the field observations and the visualisation on Google Earth. Once the classification was completed, processing was carried out to refine, evaluate the accuracy and validate the results as shown in Figure 3.

The first processing consisted of running the classified image through a 3x3 majority filter and the image pixel confusion matrix which provides statistics on the image processing. This matrix is used to determine the overall accuracy of the results obtained (total number of correctly classified pixels, Kappa coefficient) and the accuracy of each classified category, including individual accuracy (Gao & Skillcorn, 1998). The classification result was considered acceptable if the overall accuracy was above 0.80.

Assessment of the evolution of the vegetation cover on the landscape in the Bamboutos Mountains

The calculation of the rate of change between the periods 1980-2000 and 2000-2021 was carried out using the equation proposed by FAO (1996). S_1 is the area occupied by a land cover class at date t_1 and S_2 is the area of that same class at date t_2. If the rate of change is positive, then this will represent an increase in the area of the class during the period analyzed, while negative values indicate the loss of area of this class between the two dates. Values close to zero express a relative stability of the class in both periods. The overall rate of change was expressed by Equation (1) and the annual rate of change by Equation (2) (Bernier, in 1992). However, the rate of deforestation corresponds to the overall rate of change of the forest classes in the study area. The annual deforestation rate was obtained by dividing the overall deforestation rate by the number of years between the two periods studied.

$$Tg = S_2 - S_1 / S * 100 \tag{1}$$

With:

Tg: Overall rate of change;

S_1 is the area occupied by a land use class in 1980 for the period (1980-2000) and in 2000 for the period (2000-2021);

S_2 is the area occupied by a land use class in 2000 for the period (1980-2000) and in 2021 for the period (2000-2021);

S is the area occupied by a land use class in 1980 for the period (1980-2000) and in 2000 for the period (2000-2021).

$$Tc = \frac{l_2 nS - l_1 nS}{(t_2 - t_1) \times \ln e} * 100 \tag{2}$$

With:

T_c: Annual rate of change;

ln: the neperian logarithm;

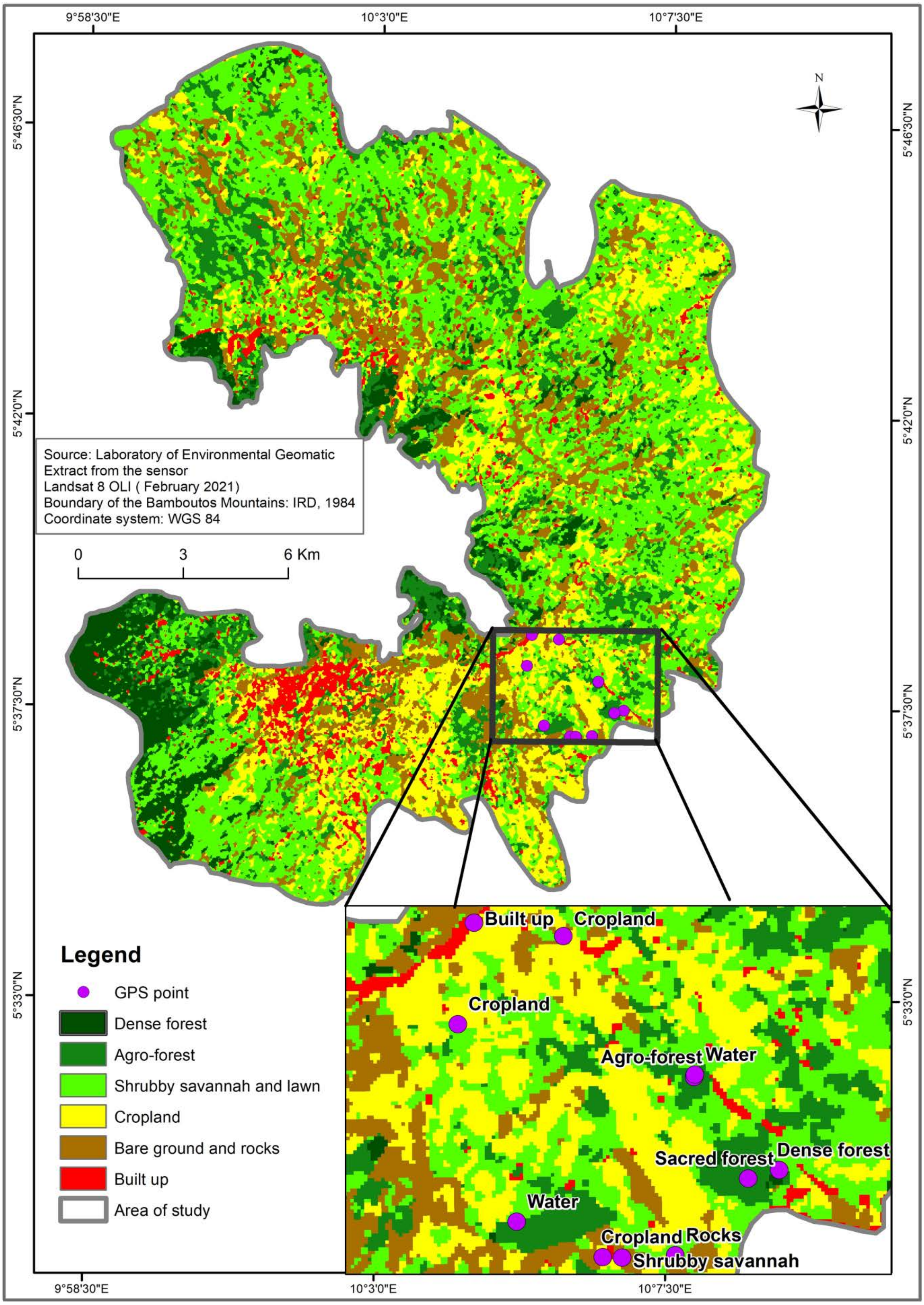

Figure 3. Treatment validation map.

e: the base for neperian logarithms ($e = 2.71828$);

t_1: Period 1;

t_2: Period 2.

2.4.2. Drivers of Land Use Change

The content analysis technique was used to describe and understand the drivers of degradation and deforestation as expressed by the different stakeholders.

3. Results and Discussions

3.1. Results

3.1.1. Land Use 1980

Table 1 shows the statistics of the land use classes in 1980.

Table 1. Statistics on land use classes in 1980.

Land use	Areas (ha)	%
Dense forest	2965.87	11.18
Agro-forests	8903.34	33.57
Shrubby savannah and lawn	9414.71	35.50
Crop land	3837.15	14.47
Bare ground/rock	1388.22	5.23
Built-up areas	10.95	0.04
Total	**26,520.23**	**100**

Analysis of this Table 1 shows that the Bamboutos Mountains landscape was heavily wooded in 1980, consisting largely of two main vegetation formations: shrub savannah and grassland, which occupied an area of 9414.71 ha, i.e., 35.50% of the total surface area of the study area, and agro-forests occupying an area of 8903.34 ha (33.57%). As for the classes of Crop land, they corresponded to 3837.15 ha or 14.47%; bare soil/rock and built-up areas corresponded to 1388, 22 and 10.95 ha respectively, i.e., 5.23% and 0.04% of the total study area. From these statistics, it can be seen that in 1980, the phenomenon of degradation was not yet perceptible in this area. Figure 4 shows the distribution of land use in 1980.

3.1.2. Land Use 2000

Table 2 shows the statistics of the land use classes in 2000.

According to this table, the landscape was becoming less forested. Dense forests had a surface area of 2,655.21 ha, i.e., 10.1% of the total area under study. Agro-forests had experienced an exponential loss of area. In fact, they represented only 19.76% of the study area. Shrubby savannahs and lawns already occupied 40.36%, i.e., 10,702.74 ha. Crop land already represented 18.78%, or 4980.21 ha. The bare soil and built-up area classes represented 2748.43 and 192.38 ha respectively, i.e., 10.36% and 0.73% of the total area. These statistics show that the landscape in 2000 was becoming highly anthropised due to the conquest of

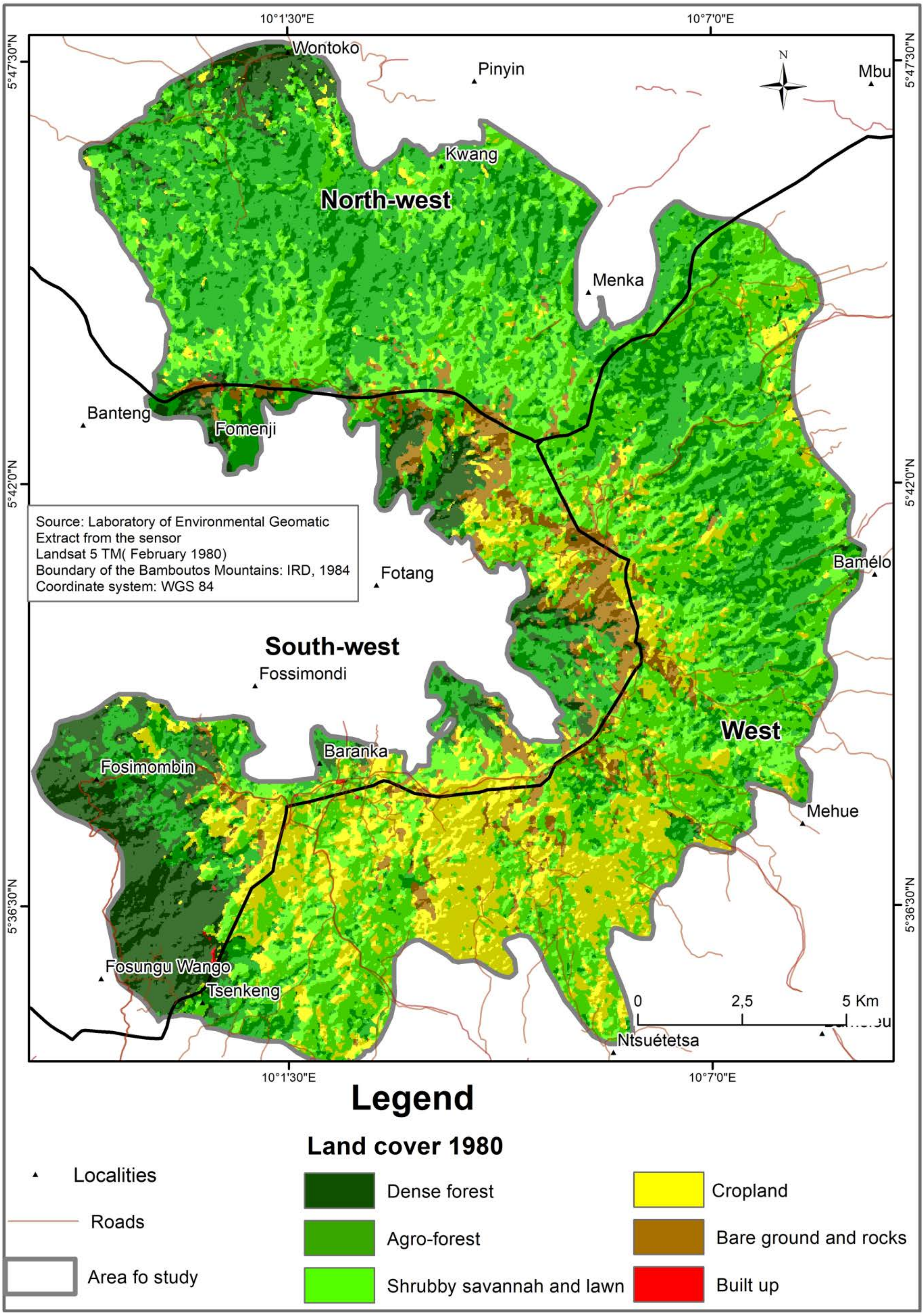

Figure 4. Distribution of land use in 1980.

Table 2. Statistics on land use classes in 2000.

Land use	Areas (ha)	%
Dense forest	2655.21	10.01
Agro-forests	5241.26	19.76
Shrubby savannah and lawn	10702.74	40.36
Crop land	4980.21	18.78
Bare ground/rock	2748.43	10.36
Built-up areas	192.38	0.73
Total	**26,520.23**	**100**

new land for construction but also for mountain farming and grazing. Figure 5 shows the distribution of land use in 2000.

3.1.3. Land Use 2021

Table 3 shows the statistics of the land use classes in 2021.

Table 3. Statistics of land use classes in 2021.

Land use	Areas (ha)	%
Dense forest	2006.25	7.56
Agro-forests	3279.49	12.37
Shrubby savannah and lawn	9902.24	37.34
Crop land	5966.32	22.50
Bare ground/ rock	3980.16	15.01
Built-up areas	1385.77	5.23
Total	**26,520.23**	**100**

Satellite image processing in 2021 shows a significant loss of vegetation cover compared to the other two periods. The landscape is less and less forested and there is a considerable drop in the area of dense forests and agro-forests. They correspond to 2006.25 and 3279.49 ha respectively, i.e., 7.56 and 12.37% of the study area. Shrubby savannahs and lawns account for 37.34%, or 9902.24 ha. Crop land occupies 22%, or 5966.32 ha. As for bare and built-up soils, they have increased exponentially and cover respectively 15.01% and 5.23% of the total study area. This situation can be explained by a strong anthropisation of the area over the years due to a double phenomenon of human settlement coupled with agricultural expansion and grazing land. Figure 6 shows the distribution of land use in 2021.

3.1.4. Summary of Land Use between 1980 and 2021

Figure 7 shows the summary of land use class statistics in the Bamboutos Mountains

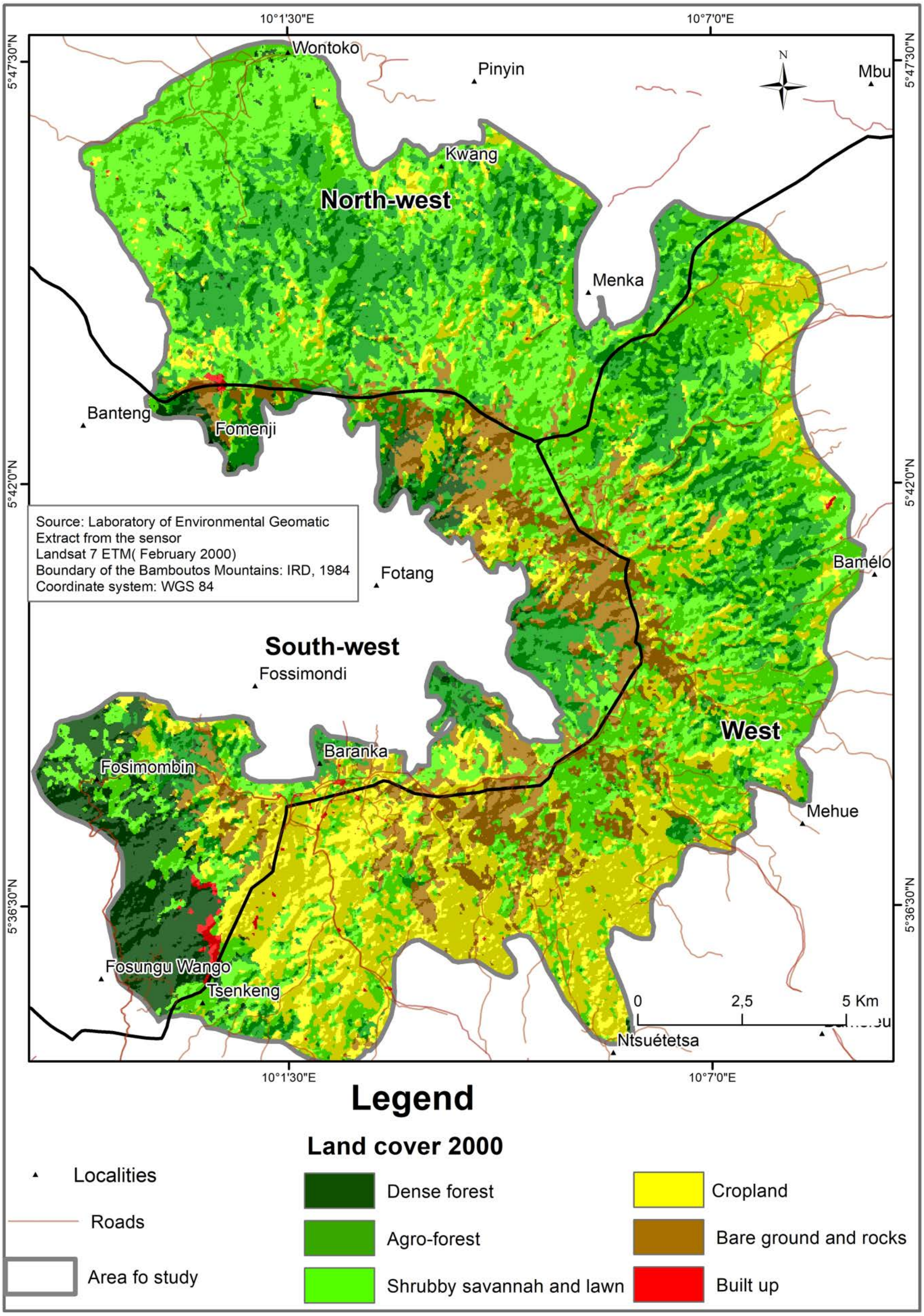

Figure 5. Distribution of land use in 2000.

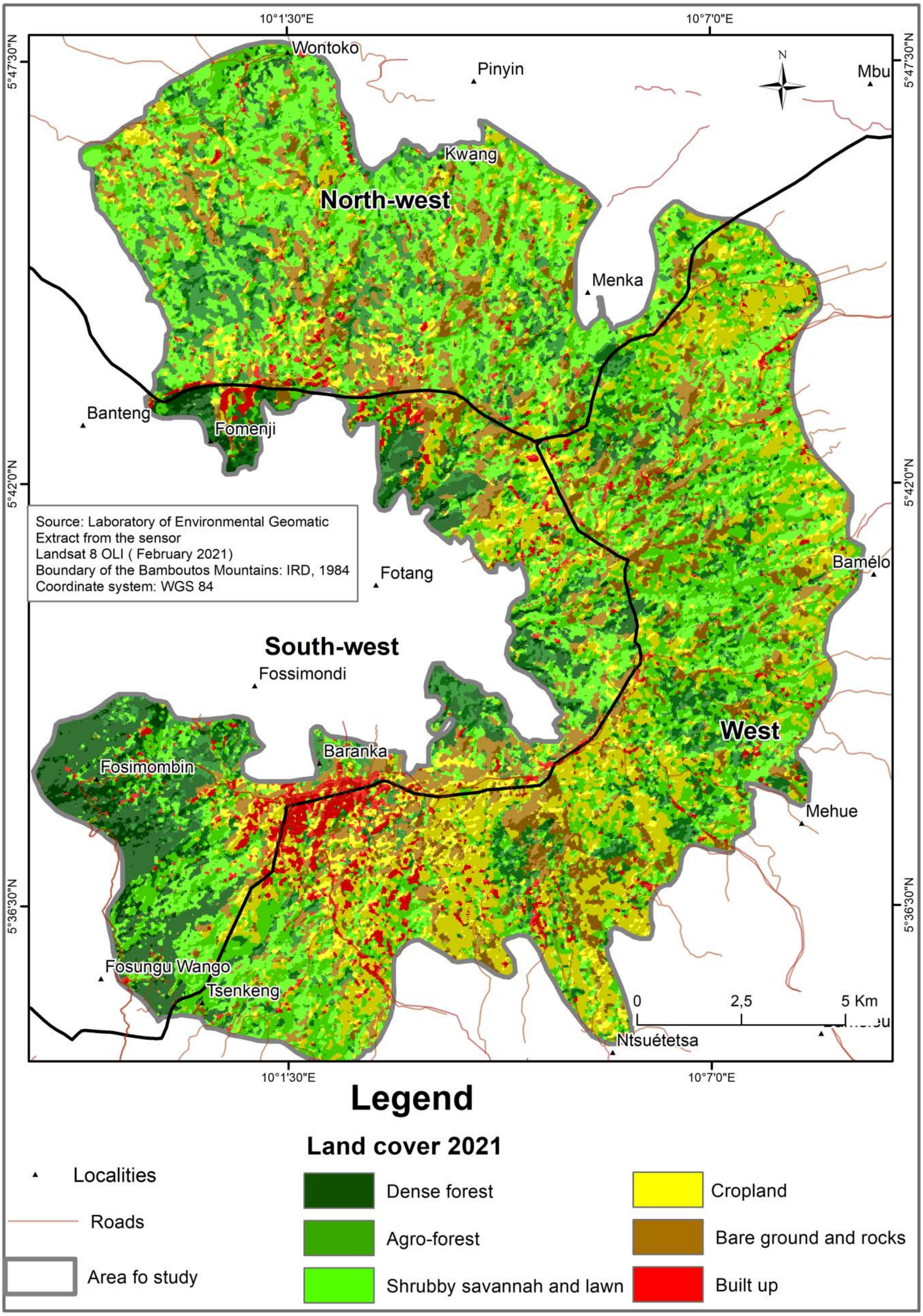

Figure 6. Distribution of land use in 2021.

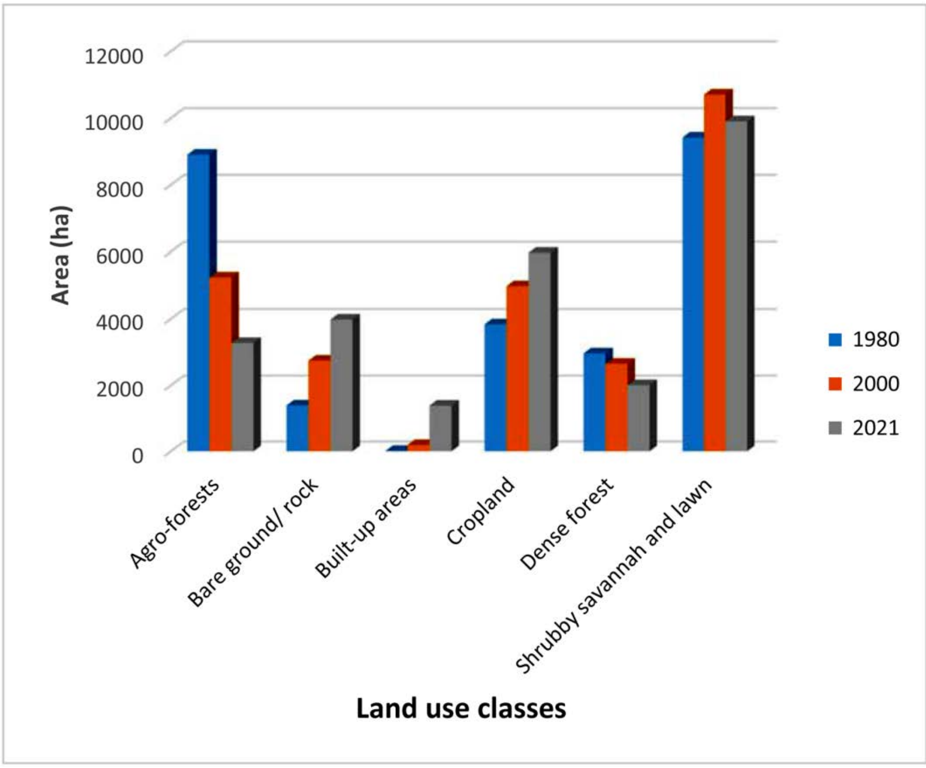

Figure 7. Summary of land use class statistics between 1980 and 2021.

between 1980 and 2021.

According to this figure, two main classes have experienced a significant regression over time: dense forests (11.18% in 1980; 10.01% in 2000 and 7.56% in 2021) and agro-forests (33.57% in 1980; 19.76% in 2000 and 12.37% in 2021). In general, the classes that have shown a clear progression are, among others, shrubby savannahs and lawns (35.50% in 1980; 40.36% in 2000 and 37.34% in 2021), Crop land (14.47% in 1980; 18.78% in 2000 and 22.50 in 2021). Bare soil (5.23% in 1980; 10.36% in 2000 and 15.01% in 2021) and built-up areas (0.04% in 1980; 0.73% in 2000 and 5.23% in 2021). Figure 8 shows the evolution of land use between 1980 and 2021.

3.1.5. Analysis of the Evolution of Land Use between 1980, 2000 and 2021

1) Analysis of the evolution of land use between 1980 and 2000

Table 4 shows the evolution of land use between 1980 and 2000.

Analysis of this table shows that between 1980 and 2000, two land-use classes experienced a regression. Dense forests lost 310.65 ha, i.e., a regression rate of 0.55% per year. Agro-forests lost 6623.08 ha, i.e., an annual loss of 2.65%. However, the other four classes have increased. These are shrubby savannahs and lawns, which increased by 2881.03 ha, i.e., an increase of 0.64% per year. Crop land have increased by 29.79 ha, i.e., 1.30% per year. For bare soil and built-up areas, these classes have increased by 1360.21 and 181.43 ha respectively, i.e., 3.42% and 14.33% per year.

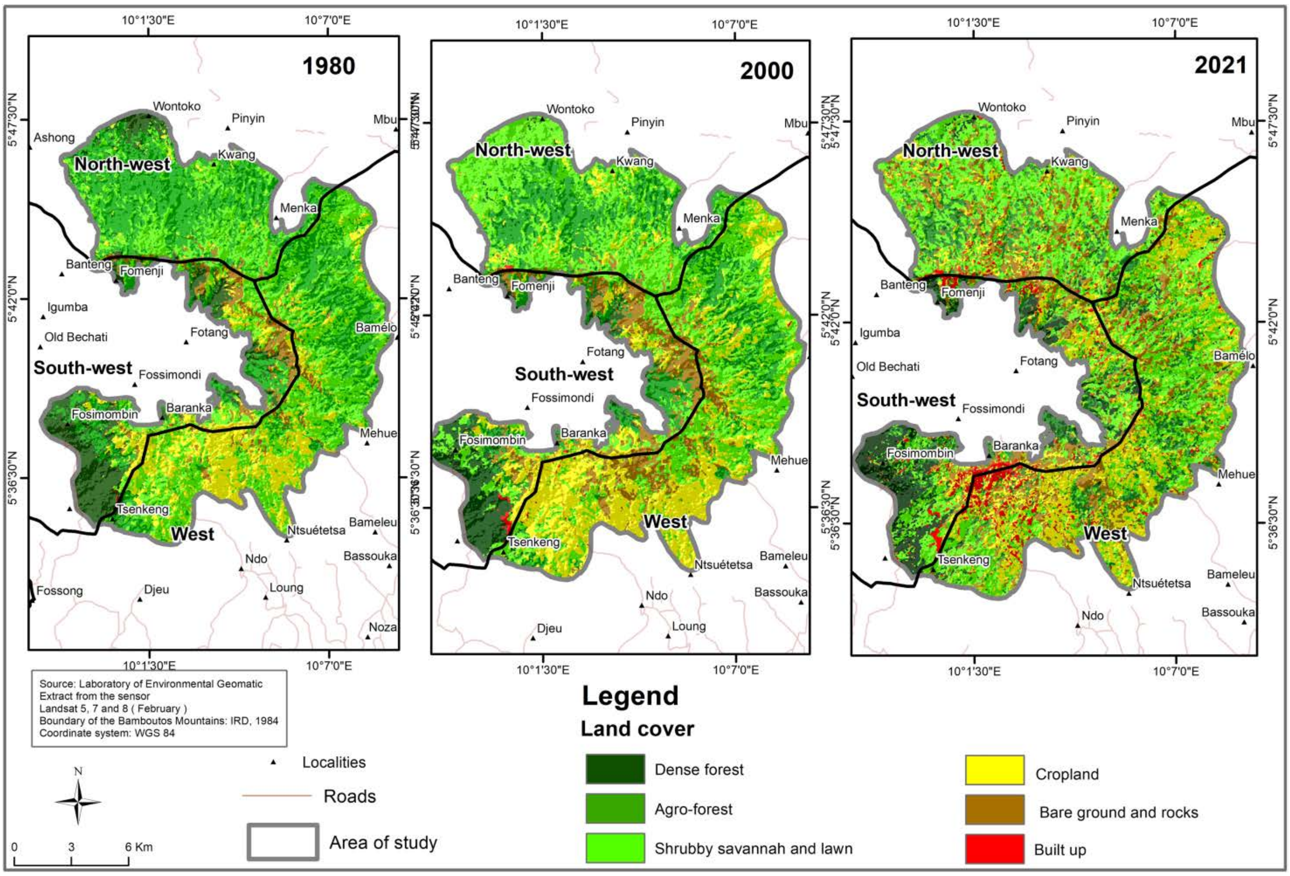

Figure 8. Summary of land use between 1980 and 2021.

Table 4. Land use between 1980 and 2000.

Land use	1980	2000	S+/−	TG (%)	TC (%)
Dense forest	2965.87	2655.21	−310.65	−10.47	−0.55
Agro-forests	8903.34	5241.26	−3662.08	−41.13	−2.65
Shrubby savannah and lawn	9414.71	10,702.74	1288.03	13.68	0.64
Crop land	3837.15	4980.21	1143.06	29.79	1.30
Bare ground/ rock	1388.22	2748.43	1360.21	97.98	3.42
Built-up areas	10.95	192.38	181.43	1656.45	14.33
Total	**26,520.23**	**26,520.23**			

S+/−: Area added or lost; TG: Overall rate of change; TC: Average annual rate of spatial expansion.

2) Analysis of the evolution of land use between 2000 and 2021

Table 5 shows the evolution of land use between 2000 and 2021.

The analysis of Table 5 shows that three land use classes have experienced a loss in terms of surface area. These are dense forests, which lost 648.97 ha, i.e. an annual loss of 1.40%. Then, agro-forests saw its area reduced by 1961.77 ha, i.e. a loss of 2.34% per year. Shrubby savannah and lawns lost 800.50 ha during this period, a loss of 0.39% per year. The classes that have progressed over time include Crop land, bare soil and built-up areas. These classes have increased and correspond respectively to an increase of 0.90%, 1.85% and 9.81% each year.

Table 5. Land use between 2000 and 2021.

Land use	2000	2021	S+/−	TG %.	TC %.
Dense forest	2655.21	2006.25	−648.97	−24.44	−1.40
Agro-forests	5241.26	3279.49	−1961.77	−37.43	−2.34
Shrubby savannah and lawn	10,702.74	9902.24	−800.50	−7.48	−0.39
Crop land	4980.21	5966.32	986.11	19.80	0.90
Bare ground/rock	2748.43	3980.16	1231.74	44.82	1.85
Built-up areas	192.38	1385.77	1193.39	620.33	9.87
Total	**26,520.23**	**26,520.23**			

3) Evolution of land transition forms between 1980 and 2021

Table 6 shows the transition matrix of land use classes between 1980 and 2021.

Table 6. Matrix of land use class transitions between 1980 and 2021.

Land transition form	Converted areas (ha)
Dense forest > Dense forest	1228.38
Dense forest > Agro forest	404.82
Dense forest > Shrubby savannah and lawn	963.78
Dense forest > Crop land	62.55
Dense forest > Bare ground/rocks	130.19
Dense forest > Built-up areas	134.60
Agro forest > Dense forest	505.31
Agro forest > Agro forest	1828.50
Agro forest > Shrubby savannah and lawn	4633.15
Agro forest > Crop land	759.37
Agro forest > Bare ground/rocks	957.30
Agroforestry > Built-up areas	203.38
Shrubby savannah and lawn > Dense forest	71.03
Shrubby savannah and lawn > Agro forest	733.12
Shrubbery savannah and lawn > Shrubbery savannah and lawn	3973.51
Shrubby savannah and lawn > Crop land	2399.56
Shrubby savannah and lawn > Bare ground/rocks	1626.45
Shrubby savannah and lawn > Built-up areas	632.59

Continued

Crop land > Dense forest	42.48
Crop land > Agro forestry	225.28
Crop land > Shrubby savannah and lawn	897.44
Crop land > Crop land	1530.93
Crop land > Bare ground/rocks	815.63
Crop land > Built-up areas	300.60
Bare ground/rocks > Dense forest	152.12
Bare ground/rocks > Agro forest	187.17
Bare ground/rocks > Shrubbery savannah and lawn	452.18
Bare soil/rocks > Crop land	148.19
Bare ground/rocks > Bare ground/rocks	403.33
Bare ground/rocks > Built-up areas	43.69
Built-up areas > Agro forest	0.01
Built-up areas > Shrubbery savannah and lawn	3.47
Built-up areas > Crop land	2.79
Built-up areas > Bare ground/rocks	0.64
Built-up areas > Built-up areas	3.49

The matrix shows that during the period 1980-2021, 2281.38 ha of dense forest remained as dense forest. However, 963.78 ha were converted into shrub savannah and grassland; 62 ha into Crop land; 130.19 ha into bare soil and rocks and 134 ha into built-up areas. Regarding agro-forests, they remained stable at 1828.5 ha. However, they were converted into other land use types: 6334.15 ha into shrubbery savannah and lawn; 759.37 ha into Crop land; 957.3 ha into bare soil and rocks and 203.38 ha into built-up areas. The shrubbery savannah and lawn class has been converted into other land use classes. These are Crop land (2399.56 ha), bare soil and rocks (1625.45 ha) and built-up areas (632.59). However, they have been converted into dense forests of 71.03 ha and agro-forests of 733.12 ha. Several land conversions have also taken place on Crop land. Indeed, they were converted into bare soil and rocks of 815.63 ha; built-up areas of 300.60 ha; shrubbery savannah and lawn of 897.44 ha. They have also been converted into agro-forests of 225.28 ha and dense forests of 42.48 ha. The latter is justified by the natural regeneration of forest areas. Bare soil and rocks remained unchanged between 1980 and 2021 on 403.33 ha. However, they have been converted into other land use classes. In Crop land (148.19 ha), in agro-forests (187.17 ha) and in built-up areas (43.69 ha).

3.1.6. Factors of Land Cover Change

The land cover dynamics observed in the Bamboutos Mountains between 1980 and 2021 are caused by many factors related to human activities. The direct factors linked to this change in vegetation cover are demographic pressure, pastoralism, lumbering and subsistence agriculture. However, subsistence agriculture remains the main cause of the land degradation in the study area. In fact, the local populations of the Bamboutos Mountains, like those of the Western highlands in general, used to practice coffee-based agroforestry system as their main activity, but since 1990, with the fall in the price of Arabica coffee many farmers have turned to subsistence farming by transforming these coffee-based agroforestry areas into Crop land.

In addition to the ever-increasing population, poverty and the need for food, has led to the conversion of forest lands into agricultural lands in order to feed the hungry months in the study area.

3.2. Discussion

Based on the mapping results, 06 land use units were identified on the Bamboutos Mountains. These units are not always well differentiated, probably because of the close spectral responses of these natural and particularly woody plant cover. These difficulties have been reported by several authors and even in other countries (Avakoudjo et al., 2014; Mamane et al., 2018). These difficulties may be related to the definition of homogeneous plots when choosing sampling sites. However, despite these difficulties, the results obtained remain satisfactory. The analysis of the 1980, 2000 and 2021 land-use maps has made it possible to highlight the evolution of these land-use units over the course of these four decades on the Bamboutos Mountains. This analysis revealed the regression of agro-forests and dense forests in favour of agricultural crop fields, Built-up areas, bare soil and shrubby savannahs and lawns. Yemmafouo et al. (2009), had already found the same results in the Tse Deng-Tametap watershed of the Bamboutos Mountains, which showed a 35% degradation of vegetation cover against an exponential growth of bare soil (66%) and habitat (699%) over a period of 19 years (1988-2007). Alontsi & Woyu (2013) also found similar results over the same period where natural forests lose area from about 45% in 1986 to 23% in 2001 and 12.56% in 2007. Similarly, similar results were observed in several other localities in Cameroon (Tanougong et al., 2019; Tsewoue et al., 2020).

The causes of the degradation of the vegetation cover in this locality are of anthropic origin, notably pastoralism, agricultural fields and settlements. However, agricultural activities are the main cause of this degradation as they are considered the main income generating activity of the local populations. Yemmafouo et al. (2009); and Ngoufo (2014) found similar results in the Bamboutos Mountains. However, this regression of natural vegetation cover is accompanied by loss of biodiversity and land degradation. An in-depth analysis of the causes of deforestation in Cameroon indicates that agriculture (with small farms of less than one hectare) accounts for more than 60% of forest cover loss. Indeed, a study conducted by the Ministry of Environment, Nature Protection and Sustainable Development (MINEPDED) in 2018, in the bimodal forest zone in Cameroon, shows that between 2001 and 2015, deforestation due to agricultural exploitation is about 220,000 ha. Similarly, similar results have been observed in several other localities in Cameroon (Solefack et al., 2018; Temgoua et al., 2018).

4. Conclusion

The study of the spatio-temporal dynamics of land use in the Bamboutos Mountains showed that two main classes have experienced a significant regression over time: agro-forests (−21.20%) and montane forests (−3.62%). In general, the classes that have shown a clear progression are bare soil (9.78%), crop land (8.03%), built-up areas (5.19%) as well as shrubby savannahs and lawns (1.84%). The regression of these particularly critical plant formations is due to several factors, the most important of which is the extension of agricultural land. This destruction of the vegetation cover leads to soil degradation and, above all, to the loss of biodiversity. This study highlights the need to establish effective restoration mechanisms for the Bamboutos Mountains. Based on the diachronic data obtained, a series of transformations can be carried out on these mountains to restore the functionality of the ecosystem considered indigenous and historical and to improve human well-being within the degraded landscape.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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