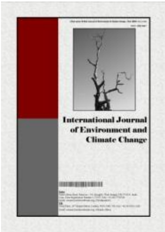

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Landscape Degradation Processes and Implications in the Western Highlands of Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Globally landscape degradation has reignited renewed interest on the restoration of degraded landscapes across sub-Saharan Africa (SSA), including Cameroon. The aim of this article is to explore the processes and implications of landscape degradation in the south eastern part of the Western Highlands of Cameroon. Specifically, the paper sought to: (i) determine the triggers and pattern of landscape degradation, and (ii) analyse the socio-ecological effects of landscape degradation. The study employed a mixed-methods approach, involving a survey of 300 households, complemented by 7 focus group discussions and 22 key informant interviews to generate primary data. The data were analysed descriptively (using tables and charts) and inferentially using the binary logistic regression model. The results revealed that population growth, poor farming methods and the expansion of settlement are the three major factors contributing to landscape degradation in the area. It further shows thatprior to settlement, most of the land was used for farming – this further justifies the fact that (poor) farming methods significantly trigger landscape degradation. Additionally, landscape degradation has introduced significant effects in the western highlands to include the expensive use of soil additives, soil erosion and soil loss, the loss of soil fertility, among others. Finally, and informed by the binary logistic regression, population characteristics strongly determine the spatial pattern of landscape degradation in the Western Highlands than topographic traits. This that farmers should be

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encouraged to engage in organic farming to promote landscape restoration. Furthermore, the practice of slash and burn and ankara should be strongly discouraged amongst farming groups.

Keywords: Landscape degradation; triggers; patterns; effects; Western Highlands.

1. INTRODUCTION

With over 9 billion people now inhabiting the planet, mother earth has the herculean task of not only providing natural resources to sustain humanity, but she is equally saddled with the responsibility to cater for the ecological imbalance produced by humanity. Although several global challenges are a cause for concern, the degradation of landscapes has received unrivalled attention due to the significant interconnectedness of this environmental issue [1, 2,3]. Landscape degradation denotes the significant decline in the productivity and ecological functionality of landscapes. This process contributes to the loss of agro-based livelihoods, including pastoral activities. It further enhances watershed degradation, translating to a decline in surface and ground water availability.

The land degradation theory of Nkonya *et al.* [4] is a useful example. The theory identifies a number of biophysical and socio-economic forces which accentuate landscape degradation [4, 5]. For instance, drivers such as the topography of the area and its exposure to soil erosion, the climatic conditions (such as temperature and rainfall) and the nature of the soil in terms of rock/soil structure serve as biophysical drivers of land degradation. Furthermore, a series of socio-demographic and economic factors such as population density, the land tenure system, the nature of access to agro-based interventions (including extension services, technology, and infrastructure) and markets were identified as causative forces in the landscape degradation process. The concomitants of rapid landscape degradation are telling: besides the destruction of terrestrial and aquatic habitats, there has been a rise in the prevalence of communicable diseases [6, 7]. Furthermore, crop failures especially in many parts of the developing world have been accompanied by rising famine, starvation and death. These environmental issues have aggravated resource related conflicts in some parts of sub-Saharan Africa [8, 5], including Cameroon [9].

Cameroon is located in the Central African sub-region. Described, as “Africa n miniature”, Cameroon represents a classical setting to understand landscape degradation processes, given it agro-ecological diversity [10, 11, 12]. Significant deforestation and land degradation in Cameroon, driven by unsustainable agricultural practices and rising fuelwood demands led to an 18.1% loss of vegetal cover between 1990 and 2010 [13, 14]. Classical examples include soil degradation in the central North of Cameroon [15], wetland degradation around the coastal low lands of Cameroon [16, 17] and land degradation in the Sahel region of Cameroon (Jamin, 2007). The trend is increasing in the Western Highlands, where significant population growth and unsustainable land use practices prevail [18, 19], making it a very difficult terrain for sustainable agricultural development [20]. The Western Highlands of Cameroon is amongst the most densely populated regions of Cameroon (128.5 inhabitants per km^2), with a key socio-economic activity being peasant farming [21]. Its predominantly difficult terrain makes agricultural activities somewhat burdensome, as landscape degradation through erosional processes continue seemingly unperturbed [22, 21]. Despite growing evidence on the concomitants of landscape degradation, knowledge gaps exists with regards to the extent to which landscape degradation occurs and the triggers of such processes in the Western Highlands of Cameroon. This paper therefore seeks to explore the landscape degradation process and implications in the Western Highlands of Cameroon. The evidence derived is useful to inform efforts towards landscape restoration in the Western Highlands agro-ecological zone.

2. STUDY AREA AND METHODOLOGY

2.1 Study Area

The Western Highlands of Cameroon significantly covers the North West and West Regions of the country. This zone is characterized by a great relief diversity, shaped by savannah vegetation, stepped plateaus, low basins and plains crossed by gallery forests.

However, few forest patches and grasslands are increasingly facing pressure from multiple stressors – thus precipitating land degradation. This area has a very rich and diversified cultural and social background. In the case of this study, the south eastern part, an area which depicts significant degradation, was selected. The study covers three sub-divisions - Mbouda, Babadjou and Santa sub-divisions (Fig. 1). These study areas (Santa, Babadjou and Mbouda) were selected based on their ecologically fragile nature, which require landscape restoration interventions, and the high rates of poverty and food insecurity. From the three sub-divisions, seven communities were selected to include Bamesso, Bamendou, and Bafounda (Mbouda), Matazem and Toumaka (Babadjou), and Santa and Akum villages (Santa). Mbouda and Babadjou sub-divisions are predominantly French speaking, while Santa sub-division is found in the English-speaking part of Cameroon.

The population census of 2010, gives the study area a growth rate of 2.6% from 2005 to 2010. Considering the 2.6% growth rate, the current population of these sub-divisions (Santa, Babadjou, and Mbouda) is estimated at around 268,351. The Mbororos are a small ethnic minority group (about 7% of the total population) and they predominantly practice cattle rearing alongside a few other non-Muslims. Although having a relatively small population, cattle rearing form part of the landscape degradation and conflict triggers of the Western Highlands [9].

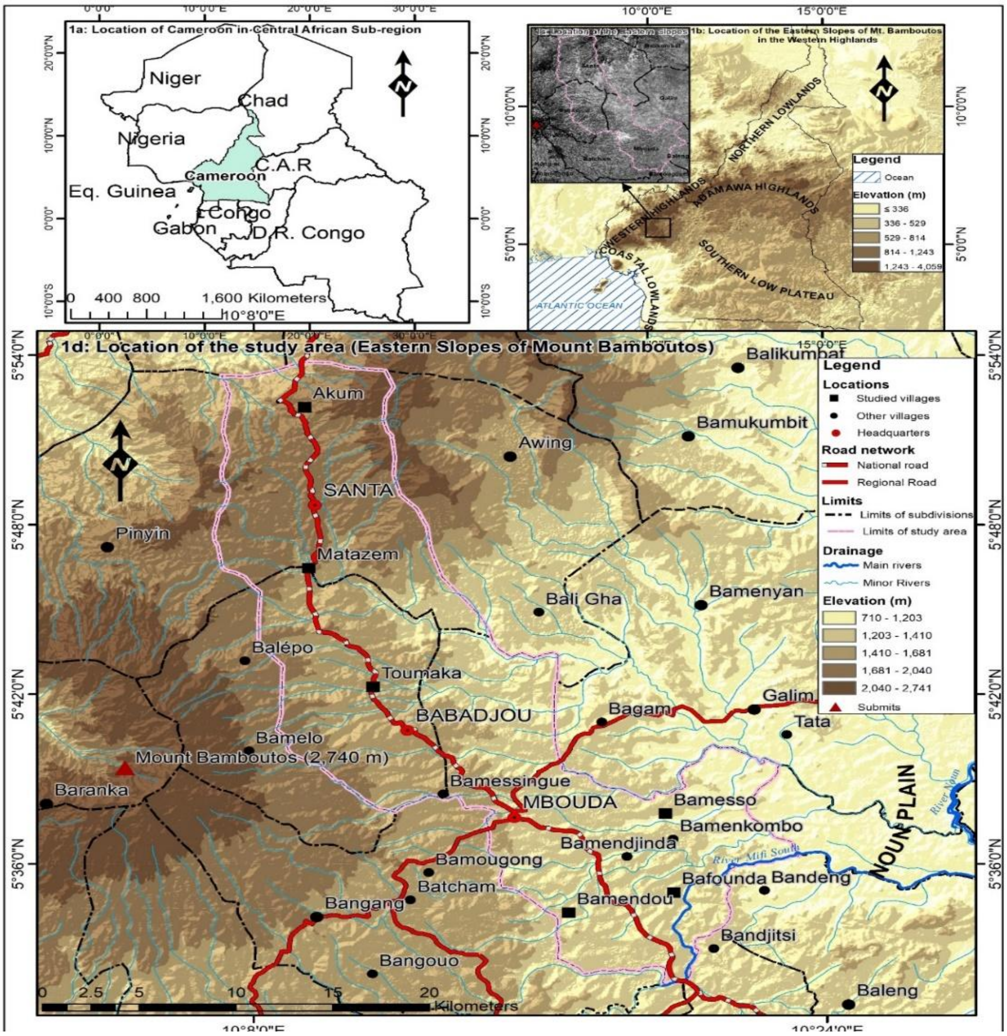

Fig. 1. Location of study area

Sources: Administrative limits of Cameroon (NIC, 2020), AW3D3O DEM (JAXA, 2019), Sentinel-2B 10m band 4 (ESA, 2020)

2.2 Research Methods

A mixed-methods approach, involving a combination of qualitative (desktop reviews, focus group discussions and interviews) and quantitative data collection methods (survey of farming households) is employed for the study. Qualitative data was obtained through focus group discussions and key informant interviews. In total, several focus group discussions (one per community) was conducted. The participants were carefully selected to include farmers, graziers and other natural resource actors. The group size ranged from 6 to 13, with discussions running for between 60 to 90 minutes. Furthermore, 22 key informant interviews were conducted with community members and landscape restoration actors (governmental and non-governmental). The interview sessions each lasted between 45 and 60 minutes. These interviewees provided good insights and a better understanding of the landscape degradation process. Qualitative data was generated using a structured questionnaire. Within each of these sub-divisions, two villages each, were randomly selected with the exception of Mbouda where 3 communities were selected. This random selection was done by listing all the villages within one sub-division, on pieces of papers and making a ballot. This gave every village an equal probability of being selected. Three instead of 2 villages were selected in Mbouda Sub-division because its total population is significantly higher than those of Babadjou and Santa. In Santa sub-division, Akum and Santa Village were randomly selected. In total, 300 households were randomly selected (Table 1).

The simple random sampling technique was employed in Mbouda and Babadjou, while the snow-ball method was used for Santa. The latter method was preferred around Santa and Akum, considering the sensitive socio-political climate linked to the on-going Anglophone crisis. Both content analysis and thematic analysis were used to treat and analyse qualitative data. Quantitative data gotten from the structured questionnaire were treated and analysed using the SPSS in two phases - descriptive and inferential analysis. Descriptive analyses centred on the presentation of data using tables, frequencies and charts. This approach enabled the description of the data obtained including their spatial presentation. The inferential analyses centred on the use of the binary logistic regression. Here, the dependent variable (land degradation patterns) took 1 for changing and 0 otherwise. By denoting P as the probability of reaching an alternative from the predictors $X_{1,}$ X_{1}……… X_n, the mathematical formula for the binary logistic regression model [23,24,25] used is expressed as:

$$Y = Logit\ (P) = \ln\left(\frac{P}{1-P}\right) = \propto\ + \beta_1 X_1\ + \beta_2 X_2 \dots\dots\dots\ \beta_n X_n \dots\dots\dots\dots\dots\dots (1)$$

Where:

P: probability that the pattern of land degradation is changing

1-P: probability that the pattern of land degradation is not changing

X_1, X_2, X_3………X_n are the different population and topographic characteristics

In the logit model (equation 1), the notations β_1, β_2……β_n (generally termed as β) denote the slope coefficients of the explanatory variables $X_{1,}$ X_1……… X_n (generally termed as X) and α is the intercept term (constant).

Table 1. Target population and sample per study site

Sub-division	Total population	Villages	Population per village	No. of households	Sample
		Bafounda	3217	537	44
Mbouda	140,000	Bamesso	1468	210	43
		Bamendou	1950	279	43
		Santa	7597	1285	50
Santa	65,645	Akum	9000	1500	50
		Toumaka	1008	168	35
Babadjou	44,198	Matazem	500	83	35
Total	249843	-	24740	4062	300

3. RESULTS

3.1 Landscape Degradation Triggers

As explained by the population, poor farming methods (reported by over 79%), population growth (reported by over 37%) and the expansion of settlement (reported by over 34%) are the three major factors contributing to landscape degradation in the area. Of key importance is poor farming methods as 52.5% of the population rated the contribution of this trigger above 75% (Fig. 2).

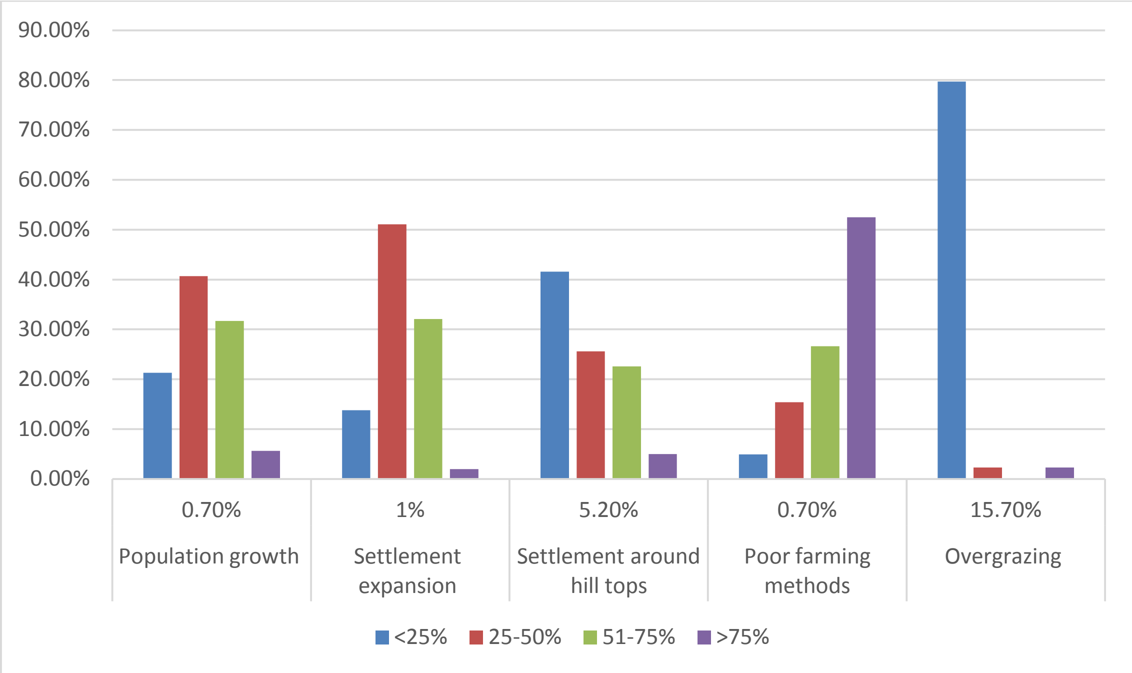

Fig. 2. Land degradation triggers in the south eastern part of the Western Highlands

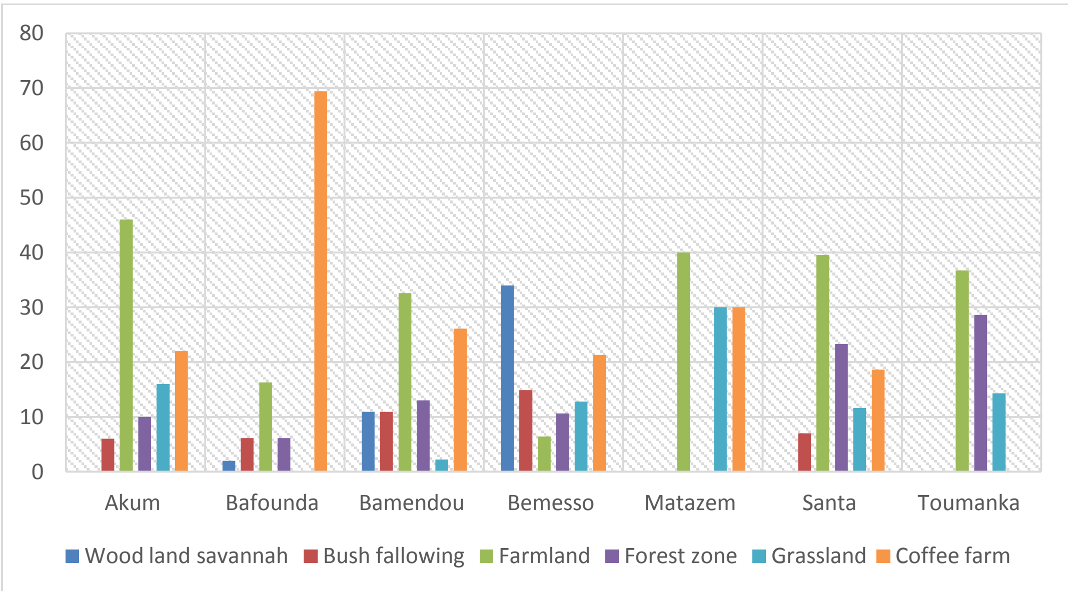

Fig. 3. Representation of individual perception on land use practices

3.2 Land Use Practices and the Trend of Landscape Degradation

To further corroborate landscape degradation, this section analyses respondents' perceptions on the use of land over the years. It later explores habitation sites and reasons for staying on the sites, problems affecting settlement and establishes the relationship between population growth and topographic site occupation. Fig. 3 presents an analysis of how land was used when respondents first settled there. It shows that the land was mostly used as farmlands in the past especially in Akum (46%), Matazem (40%) Santa (over 39.5%) as well as Toumanka (37%). This was followed by using the land as coffee farms in the past especially in Bafounda (over 69%), Matazem (30%) and Akum (over 22%).

To further corroborate this evidence, respondents provided land cover evidence prior to settlement establishment in the area. The results show that the land cover for all the different areas was forested with Bafounda and Bamesso showing the most significant forest cover (84 and 83% respectively) (Table 2).

In terms of the extension of the built-up area, Fig. 4 reveals that there has been an extension of the built up areas in these communities. In the past, this could be considered as partially built-up areas compared to the situation now. Partially built up in this case refers to areas with a very low housing concentration and density or better still, areas with a mix or blend of several major land uses like forests, grassland, farmland and houses/buildings, while built-up areas refer to areas predominantly covered by buildings. This is especially significant in Bamesso where close to 96% of the respondents agreed that the community is almost completely covered by the built-up area. This was followed by Bamendou (over 78%), Bafounda (73.5%) and Matzem (70%).

Table 2. Perception of land cover situation prior to settlement in the study sites

	Forested (%)	Grassland (%)	Farmland (%)
Sample	76.5	22.1	1.4
Akum	70	30	0
Bafounda	83.7	14.3	2
Bamendou	69.9	30.4	0
Bemesso	83	17	0
Matazem	70	30	0
Santa	76.8	20.9	2.3
Toumanka	77.6	18.4	4.1

Note: $X^2 = 28.909$, $p = 0.050$

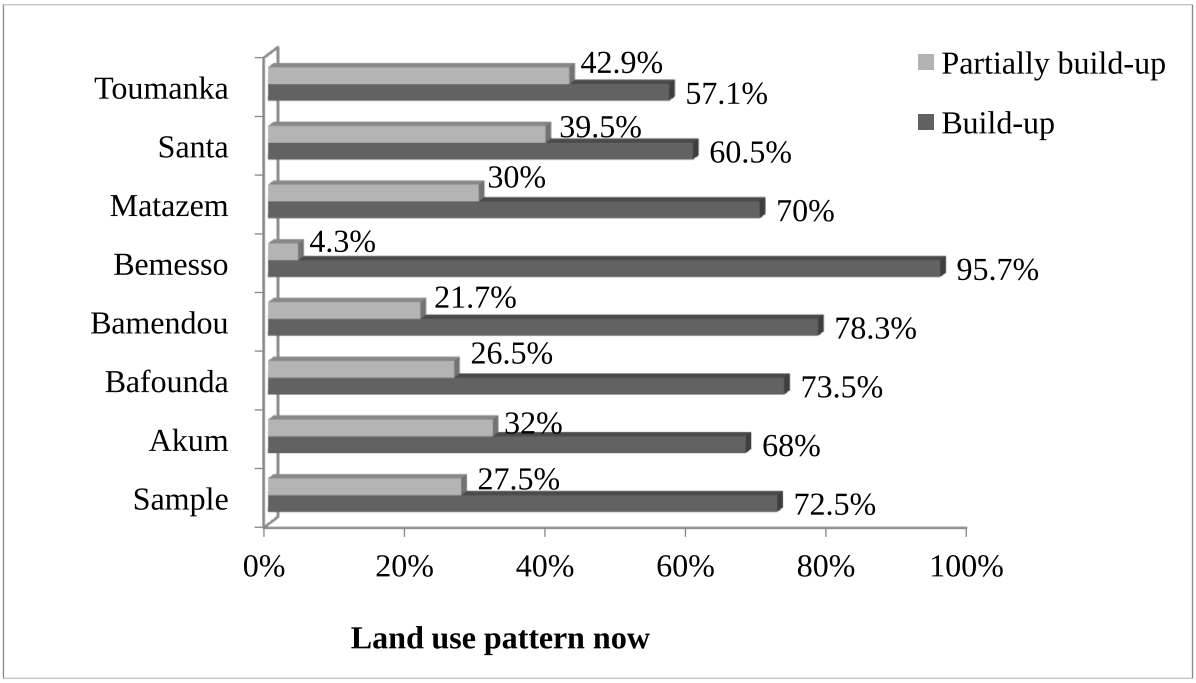

Fig. 4. Land Occupation by built-up and partially built-up areas in the study sites

Table 3. Effects of landscape degradation in the study sites

Effects / evidence/ aspects of degradation	Zero response (%)	<25%	25-50%	51-75%	>75%
Changes in local climate	2	20.6	29.8	33.8	13.8
Decline in crop production	0	1.6	21.6	54.1	22.6
Decline in livestock production	12.8	80.3	6.2	0.7	0
Food insecurity and rise in food costs	2.6	20	47.2	24.3	5.9
Expensive use of soil additives	0	5.2	5.6	28.5	60.7
Soil erosion and soil loss	0	12.7	33.8	31.5	22
Loss of soil fertility	0	4.7	23.9	27.5	43.9
Decline in water spots	0	18.7	14.4	40.3	26.6
Loss of grassland	0	62.3	20.7	13.8	3.3
Loss of forests	0	20.7	37	17.7	24.6

Table 4. Perception on the changes in the flow characteristics of some streams (1991-2021)

Stream	Town	1991-2001	2001-2011	2011-2021
Big River Mtazem	Babadjou	Continuous (high volume)	Continuous (high volume)	Continuous (reduced volume)
Small River Matazem	Babadjou	Continuous (high volume)	Continuous (reduced volume)	Seasonal flow
River 24 Escaliers	Mbouda	Continuous (high volume)	Continuous (moderate volume)	Seasonal flow
NNO River	Mbouda	Continuous (high volume)	Continuous (reduced volume)	Continuous with drastic reduction in volume

Source: Field Work 2020

3.3 Effects of Landscape Degradation

Due to landscape degradation, farmers have resorted to the intensive application of soil additives (over 89%). While this assures short term productivity, it has long term effect on the soil and also degrades the water systems. Food insecurity and rise in food costs and changes in local climate were reported as the effects of landscape degradation (Table 3).

From Table 3, 22% of the total population experienced soil erosion and soil loss (rated above 75%), 31.5% held that it is rated between 51%-75%, 33.8% placed it between 25-50%. Finally, 12.7% of the population rated it below 25%. Regarding the soil fertility loss, close to 44% think the percentage of soil fertility loss rates below 25%. On the other hand, less than 5% of the population think that the loss of soil fertility is rated at below 25% Apparently, there is not much evidence of grassland loss as more than half (62.3%) of the population think it rates below 25%, 20.7% rate it between 25-50%, 13.8% rate it at 51-75% and only 3.3% rate the loss of grassland at above 75%. For forest land, 20.7% rate its loss at below 25%, 37% at between 25-50%, 17.7% at 51-75% and 24.6% at above 75%.

Another effect of landscape degradation is linked to local climatic changes. The analysis reveals that close to 34% of the population rate this effect at 51-75%, while 14% rate it above 75%. However, 20.6% think the effect stands at less than 25%. Climatic effects, particularly rising temperatures and unreliable rainfall also contributes to the decline in water spots as an effect of landscape degradation. Close to 19% of the population rate this effect at below 25%, while 40.3% consider the effect under the 51-75% range. Additionally, less than 30% of the population rate the effect above 75%. The decline in water spots is further buttressed by the drastic reduction in the flow characteristics of certain streams in the study sites (Table 4).

Besides the above effects, landscape degradation also leads to a decline in crop production. All respondents indicated that crop production has dropped due to other effects of degradation. To this, only 1.6% of the population rate a decrease in crop production at below 25%, while 21.6% of the population rate it between 25-50%, 54.1% rates this at the 51-75% range, and

22.6% of the population rate it at above 75%. Regarding a decline in livestock production, 80.3% rated this effect at below 25%. Only 6.2% rate this between 25-50% and the remaining 0.7% rate it between 51-75% (Table 3). One of the expected results of a decline in crop production is food insecurity. This is mirrored through a rise in the prices of farm produce (Table 5). Twenty percent of the population rated the degree of food insecurity at below 25%, 47.2% of the population rate it at 25-50%, 24.3% of the population rate it between 51-75% and the remaining 5.9% of the population rate it above 75%.

Table 5. Decline in crop output and changes in price for major crop types in the study sites

Crops	Prices before 1990 (FCFA)	Prices in 1990 (FCFA)	Prices in 2000 (FCFA)	Prices in 2010 (FCFA)	Prices in 2020 (FCFA)
		Santa			
1 bucket of maize	250-450	500	1500-2000	2000	2500
1 bucket of Irish potatoes	150-300	700	1200	2000	3000-3500
1 bucket of cocoyams	150-300	350	1500	2000	2500-3000
1 bucket of cassava	100	300	1500	2000	2500
1 bucket of yams	200	200-250			
1 basket of tomatoes	25-250	700	2500	4000	6000
1 bag of cabbages	10-100	500	1500	2000-2500	3000-4000
		Babadjou			
1 bucket of maize	450	800	1500	1500-2000	200-3500
1 bucket of Irish potatoes	500	700	1200	1500-2000	2500-3000
1 bucket of cocoyams	500	600-700	1500	1700-2500	3000
1 bucket of cassava	150	500	1500	2000-2500	3000
1 bucket of yams	50	300	750	900	1500
1 basket of tomatoes	400	600	1000-1500	1000-2000	1500-3000
1 bag of cabbages	200	200	300	500	1000
		Mbouda			
1 bucket of maize	300	500	1000-1500	1500-2000	2200
1 bucket of Irish potatoes	150-200	250	500-800	1500	3500
1 bucket of cocoyams	300	350	500	2000	4000
1 bucket of cassava	50	150	400	1500	3000
1 bucket of yams	50-100	100	400	2000	3000
1 basket of tomatoes	100	150	500	1500-2000	2500-3000
1 bag of cabbages	50-75	100	500-700	2000	3500

Table 6. Determinants of the spatial pattern of landscape degradation

	Variable	B	S.E.	Wald	df	Sig.	Exp(B)
Population Characteristics	Gender	.613	.474	1.673	09	.196	1.846
	Age of household head	.370	.297	1.551	09	.213	1.448
	Literacy level	.511	.257	3.964	09	.046	1.667
	Occupation	.077	.240	.102	09	.750	1.080
	Marital status	-.062	.431	.021	09	.885	.940
	Number of years live in community	.364	.178	4.179	09	.041	1.439
	Household size	.031	.055	.329	09	.566	1.032
Topographic trends	Topography	.175	.272	.415	09	.519	1.192
	Fertile soils	.068	.324	.044	09	.834	1.070
	Proximity to daily activities	-.014	.273	.003	09	.958	.986
	Constant	-2.557	1.524	2.814		.093	.078

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	10.572	09	0.079
	Block	10.572	09	0.079
	Model	10.572	09	0.079

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	151.790[a]	.045	.103

The binary logistic regression results (Table 6) indicate that 6 of the 7 (85.7%) population characteristics (gender, age, literacy level, main occupation, number of years living in the community and the household size) and 2 of the 3 (66.7%) of the topographic characteristics (topographic nature of the land and fertility of the soils) determine the spatial patterns of landscape degradation in the south eastern part of the Western Highlands.

The analysis indicates that the magnitude of the contribution of the population characteristics is generally higher than that for the topographic trends in determining the spatial patterns of landscape degradation in the south eastern part of the Western Highlands. More so, two of the population characteristics (literacy level; Beta = 0.511 and the number of years living in the community; Beta = 0.364) showed significant contribution at 5% level towards increasing landscape degradation.

4. CONCLUSION

Landscape degradation continues to receive unrivalled attention due to its significant interconnected nature. This study sought to: (i) determine the triggers and pattern of landscape degradation, and (ii) analyse the socio-ecological effects of landscape degradation in the south eastern part of the western highlands of Cameroon. Based on the analysis, the following conclusions are derived: Firstly, on the triggers of landscape degradation, it can be concluded that population growth, poor farming methods and the expansion of settlement are the three major factors contributing to landscape degradation in the area. Of key importance is poor farming methods since this is a predominantly agrarian setting. Secondly, on the land use practices, prior to settlement, most of the land was used for farming – this further justifies the fact that (poor) farming methods significantly trigger landscape degradation. Additionally, there has been a significant extension of the built up area in these communities. This is especially significant in Bamesso, Bamendou, Bafounda and Matzem, with at least 70% of respondents affirming this. Thirdly, landscape degradation has introduced significant effects in the western highlands to include the expensive use of soil additives, soil erosion and soil loss, the loss of soil fertility, reduction in the flow of streams, a decline in crop production and changes in local climatic conditions. Additionally, the decline in food production has led to a rise in the prices of farm produce. Rising food costs have been reported, with close of 50% of the population acknowledging a rise in the price of staple food as an effect; this is rated at between 25-50%. Finally, and informed by the binary logistic regression, conclude that population characteristics strongly determine the spatial patterns of landscape degradation in the Western Highlands than topographic traits. There is therefore a strong need for landscape restoration and by doing so, we consider the different landscape restoration practices, what determines them and what the hitches in implementing them are.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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