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Physiographic Potentials and Spatial Agricultural Dynamics in The Menchum River Basin, Cameroon

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Abstract

Whilst agriculture has flourished in most River Basins of the World for socio-economic sustenance, the exploitation of river basin potentials for agriculture remains crucial in ensuring food security. This study explores the influence of physiographic factors, particularly topography and soil properties, on agricultural dynamics within the Menchum River Basin, Cameroon. Using both quantitative and qualitative methods, data was collected from 239 agriculturalists involved in slope cultivation across three agro-ecological zones: Bamenda, Bafut, and Menchum Valley. Landsat satellite imagery was utilized to map physiographic variations and correlate farmland distribution patterns with slope gradients. The research employed descriptive and inferential statistical techniques, including Pearson Product Moment Correlation, to assess the relationship between slope gradient and cropland density. The results indicate that topography and soil fertility play a critical role in determining crop distribution and farming practices. However, the study reveals a disconnection between land suitability and crop selection, particularly in areas with steep slopes and limited soil fertility. This misalignment leads to inefficient land use and environmental degradation. Therefore, it is recommended that agricultural practices in the basin be better aligned with physiographic constraints, advocating for the adoption of sustainable land management practices such as terracing to reduce soil erosion and improve land productivity.

Keywords: Physiographic factors, Spatial agricultural dynamics, Slope cultivation, Land use patterns, Menchum River Basin

1. Introduction

Agriculture remains a cornerstone of rural livelihoods and economic development across much of the world, particularly in Sub-Saharan Africa, where over 70% of the population depends on land-based activities (World Bank, 2007). Rain-fed farming dominates the region, accounting for approximately 97% of cultivated land (FAO, 2019), and its performance is intricately tied to natural environmental variables such as topography, soil, and climate. These physiographic factors are not only essential for determining land suitability but also for influencing spatial patterns of agricultural land use, crop type distribution, and productivity levels (Chen et al., 2015; Akhtaruzzaman et al., 2014). In river basin ecosystems, where elevation gradients, geomorphic conditions, and water availability are highly variable, the interrelations between physical geography and agricultural practices become particularly significant (Jaksic et al., 2021). As population pressures intensify and the demand for food rises, understanding the role of physiographic controls in shaping agricultural dynamics is important for sustainable land management and achieving global food security targets, including the Sustainable Development Goals (FAO, 2019; UNDP, 2025).

In many African river basins, agricultural production has lagged behind demographic growth, partly due to limited adaptation of land use practices to environmental constraints. This is evident in the Menchum River Basin in northwestern Cameroon, where the physical diversity of the landscape, ranging from steep slopes and undulating highlands to low-lying alluvial plains, presents both opportunities and challenges for agricultural development. Although the region is characterized by high agricultural potential due to its fertile soils and adequate rainfall, the use of land is often sub-optimal, with cultivation expanding into unsuitable areas prone to erosion and degradation (Tening et al., 2023; Fouodji et al., 2024). In countries such as Nigeria, Kenya, Botswana, and Chad, much of the cultivated land lies along riverbanks and intersperses with grasslands and woodlands, and where terrain exceeds 15° slope, farming typically involves terracing or slope modification (Chen et al., 2015). However, in Menchum, such practices are inconsistently applied, and crop choices are frequently mismatched to topographic and soil conditions.

Numerous studies have illustrated the importance of physiographic factors in shaping spatial agricultural dynamics. For instance, slope gradients and elevation have been shown to influence not only soil depth and fertility but also the types of crops that can be successfully cultivated, as seen in the East African Highlands, Mekong Delta, and Southern Brazil (Tesfaye et al., 2024; Nguyen et al., 2025; Ribeiro & Martins, 2024). Furthermore, the flow of water from upper to lower slopes often contributes to soil nutrient redistribution, which can cause significant variation in soil quality across short distances (Akhtaruzzaman et al., 2014). Recent advancements in geospatial analysis tools, particularly GIS and remote sensing, have enabled more precise mapping of such physiographic variables and their correlation with land-use patterns (Banerjee & Das, 2025; Mekuria et al., 2023). Despite this growing body of research, integrated spatial-environmental studies remain scarce in Cameroon, where soil, topography, and climate are often assessed in isolation without considering their combined effects on agricultural performance (Nkeng et al., 2025).

This analytical gap is particularly problematic given the increasing pressure on land and the urgent need for targeted agricultural policy interventions. Although it is widely recognized that topography and soil attributes influence agricultural land use, the specific mechanisms through which these physiographic elements shape spatial crop dynamics in the Menchum River Basin are underexplored. Moreover, there is limited understanding of how physiographic constraints can be leveraged to optimize land-use allocation and crop selection across different zones of the basin. Without a detailed, spatially explicit understanding of these dynamics, regional agricultural strategies risk continuing a trajectory of inefficiency and ecological degradation.

This paper aims to assess the physiographic control potentials and their influence on spatial agricultural dynamics in the Menchum River Basin, Cameroon. Grounded in land evaluation theory, which promotes the assessment of land based on biophysical and socio-economic factors, and informed by the concept of environmental determinism, this research employs geospatial analysis to investigate the interrelationship between terrain, soil properties, and land use patterns. By identifying the spatial expression of physiographic factors and their influence on crop selection and distribution, this study seeks to inform sustainable agricultural planning and contribute to broader development objectives in Cameroon and comparable regions.

2. Theoretical Construct

2.1 Land Evaluation Theory

Fundamentally, the Land Evaluation Theory rests on several key assumptions. First, it posits that land use is driven by specific human needs and must be evaluated relative to a particular purpose, typically for defined crop types or agricultural activities. Second, it emphasizes the alignment of both physical (topography, soil, climate) and socio-economic (market access, labor, infrastructure) factors to determine suitability. Third, the theory acknowledges that land suitability is contextual and not absolute; the same piece of land may be suitable for one crop and unsuitable for another. Lastly, it assumes that certain land limitations can be mitigated through human intervention, such as terracing or irrigation, thereby enhancing the land's agricultural potential (Dent & Young, 1981).

Despite its wide applicability, the theory has been subject to several criticisms. One major limitation is its initial overemphasis on biophysical parameters, often at the expense of local socio-economic realities. This has led to challenges in implementation, particularly in developing regions where resource constraints and traditional practices heavily influence land use decisions. Additionally, the theory has been critiqued for its static nature, which does not adequately account for dynamic variables such as climate change, land degradation, or shifting land tenure systems (Jaksic et al., 2021). There is also a perceived technocentric bias, as the theory often assumes that farmers have access to the technical means required to modify or improve land conditions. Furthermore, the traditional top-down application of land evaluation has frequently excluded local knowledge, which is vital for the sustainability of land use practices (UNDP, 2025).

In the context of the Menchum River Basin in Cameroon, the Land Evaluation Theory is especially relevant for understanding how physiographic factors influence spatial agricultural dynamics. This region is characterized by diverse elevation gradients, variable slopes, complex geomorphological features, and heterogeneous soil types. These physical characteristics directly affect the types of crops that can be grown, the intensity of cultivation, and the spatial distribution of agricultural activities (Nkeng et al., 2025; Tening et al., 2023). By applying the principles of land evaluation, researchers can assess the agricultural potential of different physiographic units, determine their suitability for specific crops, and recommend targeted land management strategies. Such assessments are essential for sustainable land use planning, especially in areas experiencing rapid population growth and increasing food demand.

To address the limitations of the traditional FAO framework and to better reflect the complexity of the Menchum River Basin, this paper proposes the Integrated Land Evaluation and Agricultural Dynamics Model (ILEADM). This conceptual model expands the classic land evaluation approach by incorporating spatial analysis tools such as GIS and remote sensing, as well as socio-economic variables like labor availability, access to markets, and infrastructure. The ILEADM framework evaluates land suitability using multi-criteria decision analysis (MCDA), overlaying physiographic variables (e.g., slope, elevation, drainage) with climatic and land use data to generate suitability classes ranging from highly suitable (S1) to not suitable (N). This model enables a dynamic, data-driven, and participatory approach to land evaluation, offering real-time insights into how topographic variation shapes agricultural performance and potential.

3. Material and Methods

3.1 Study Area

The Menchum River Basin is broadly situated between latitudes 5°25′ and 6°15′N, and longitudes 9°07′ and 10°21′E. It is bordered by three administrative divisions within the North West Region of Cameroon. Specifically, the basin is bounded to the north-east by Boyo Division, to the north-west by Momo Division, and to the south-east by Mezam Division (Figure 1). The Menchum River Basin extends from the outskirts of Mankon, passing through the Bafut Sub-Division and into the Menchum Valley Sub-Division. Its approximate surface area is 2,116 km² (Ndenecho, 2012).

As the largest river basin in the region, it represents a significant area for potential development. Tthe Menchum River Basin is among the most agriculturally productive basins in Cameroon. It supports extensive agricultural activities, including seasonal crop cultivation and livestock rearing, both for subsistence and commercial purposes. However, the basin exhibits a diverse physiographic landscape, with elevation varying from approximately 396 to 3,000 meters above sea level.

Such variations in physiography indicate that agricultural activities across the basin are not uniform, thereby contributing to fluctuations in productivity within the river basin. The diverse physical landscape also implies that key land resources, such as soil type, moisture content, and fertility, are unevenly distributed, consequently influencing the spatial dynamics of agriculture throughout the basin.

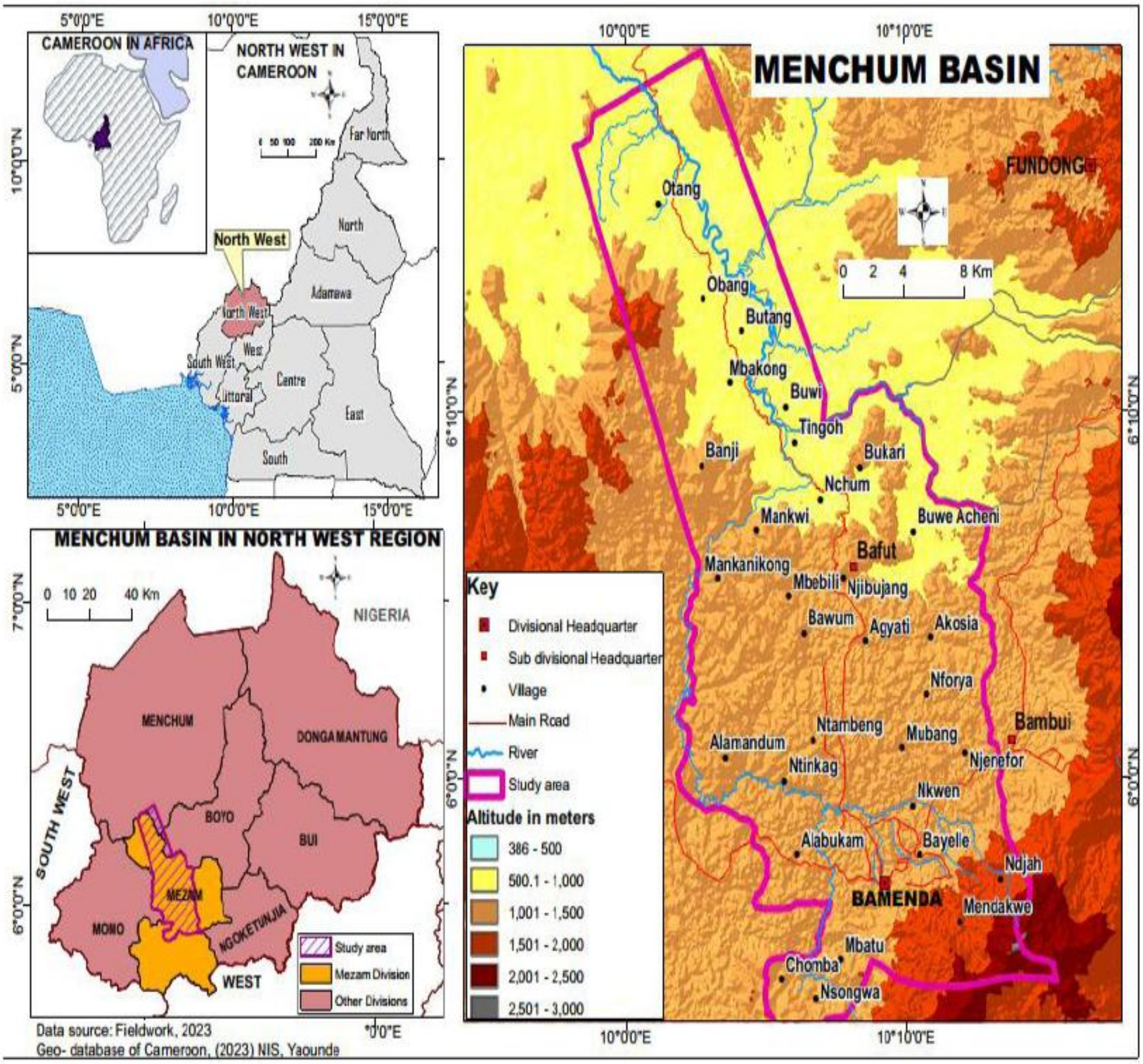

Figure 1. Location of Menchum River Basin in the North West Region of Cameroon

Source: Geo database of Cameroon, 2023 NIS,Yaounde

3.2 Methods

The paper adopts both quantitative and qualitative research approaches to investigate spatial agricultural dynamics within the Menchum River Basin. The quantitative component employed a cross-sectional survey design, with data collected through the administration of 239 structured questionnaires to agriculturalists engaged in slope cultivation across three agro-ecological zones: Bamenda, Bafut, and Menchum Valley. Stratified and simple random sampling techniques were used to ensure fair representation across zones, while purposive sampling was applied to target only respondents actively involved in slope farming. In addition to the survey, field observations were conducted to gather firsthand information on topographic variations and land-use practices across different slope gradients.

For the spatial analysis, Landsat satellite imagery was utilized to identify physiographic variations and to map slope gradients throughout the study area. These images were used to correlate farmland distribution patterns and crop types with specific slope features. Given the seasonal and individual variability in slope cultivation practices, a direct map-to-map comparison of farmland extent was not feasible; instead, interpretations were based on observed trends, field data, and farmer responses. Data analysis combined descriptive statistics, presented in tables and figures for clarity, with inferential techniques. Specifically, the Pearson Product Moment Correlation was applied at the 0.05 significance level to test the relationship between slope gradient and cropland density, validating the hypothesis that physiographic conditions significantly influence agricultural land-use patterns in the region.

4. Results and Discussion

4.1 Results

The findings presented examine the influence and potential of physiographic configuration in shaping agricultural dynamics within the Menchum River Basin. Particular attention is given to the physiographic segmentation and the distribution of crop types across the three agro-ecological zones: Bamenda, Bafut, and the Menchum Valley. The paper focuses on two main physiographic factors that govern spatial agricultural patterns in the basin, namely, topographic characteristics and soil properties.

4.1.1 Topographic Segmentation and Agro-Potentials in the Menchum River Basin

The physiographic features under consideration include the landforms of the region, hills, valleys, and plains, which constitute the principal topographic elements of the basin. These topographic forms exert a significant influence on the spatial distribution, nature, and intensity of agricultural activities. The paper reveals that the Menchum River Basin is characterised by a diverse topographic configuration, ranging from low-lying plains and valleys to gentle slopes and mountainous terrains (Figure 2). This varied landscape, extending from east to west and north to south, plays a crucial role in determining agricultural types, land use patterns, and productivity due to the differing land potentials across the basin.

Topographic analysis was undertaken using Geographic Information Systems (GIS) and ASTER image processing, providing detailed insights into the altitudinal and spatial variations within the basin. This analysis enabled the identification of three distinct agro-ecological zones based on elevation and topographic segmentation: the lower zone (Lower Menchum Valley), the middle zone (Intermediate Bafut), and the upper zone (Upland Bamenda). The Lower Menchum Valley spans an area of approximately 750 km², the Intermediate Bafut zone covers 683 km², and the Upland Bamenda zone extends across 984 km². Altogether, the Menchum River Basin encompasses a total surface area of 2,417 km².

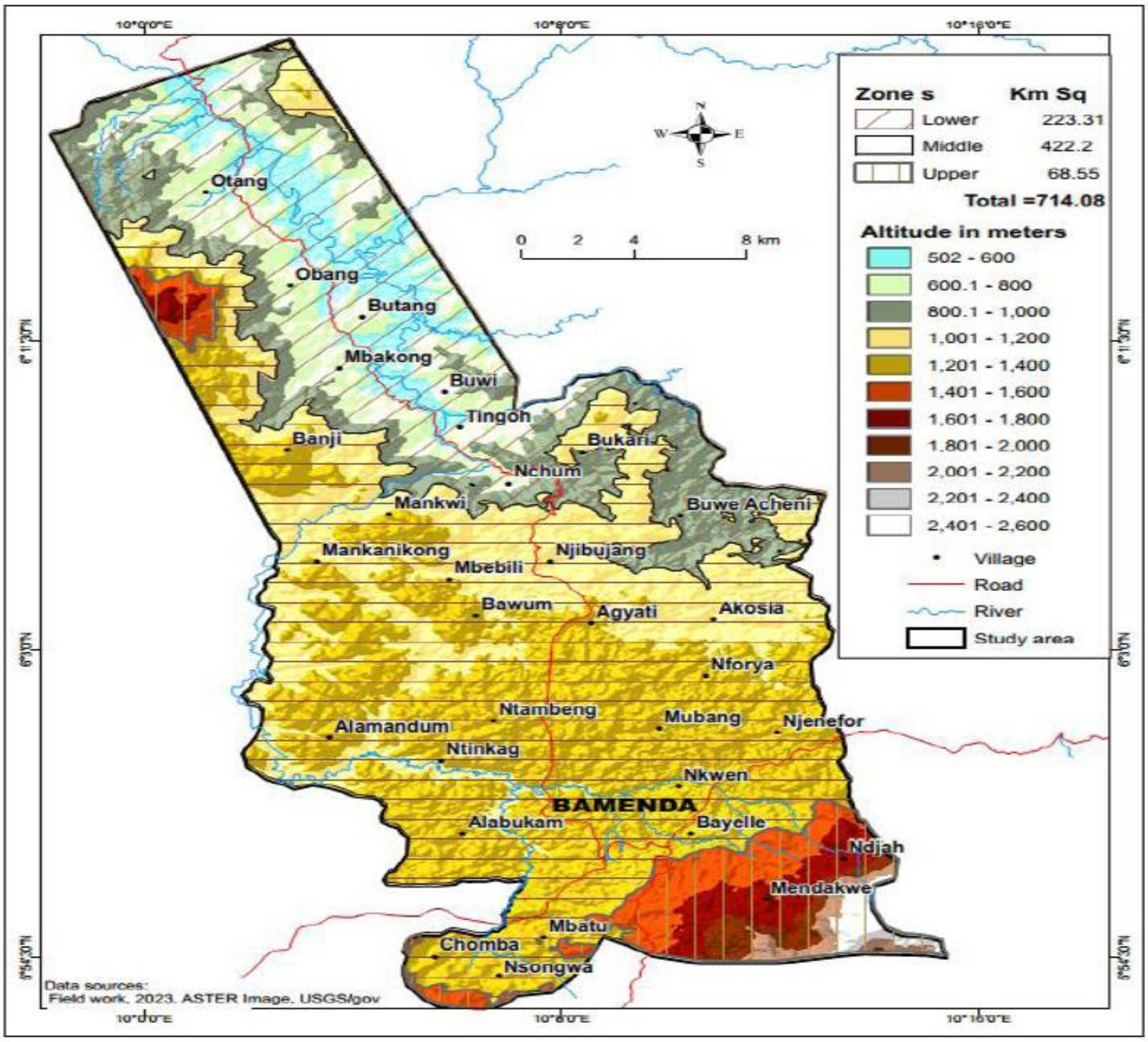

Figure 2. Topographic stratification of the Menchum River Basin

Source: ASTER Image, USGS/gov, (2023)

Table 1 presents an analysis of the altitudinal variation within the Menchum River Basin. The results indicate that elevation varies significantly across the different agro-ecological zones, with altitude generally increasing from the Lower Menchum Valley towards the Upland Bamenda zone. The Lower Menchum Valley, located in the north-eastern part of the basin, lies at an altitude of less than 800 metres above sea level. This zone includes areas such as

Tingoh, Buwi, Mbakong, Butang, Obang, Otang, Bangwe, and Bu. Covering a surface area of 750 km², the Lower Menchum Valley accounts for approximately 31.03% of the total area of the river basin. Despite its relatively low elevation, this zone is bordered by several highland regions, particularly in the south-west, south-east, and parts of the north-east. These surrounding highlands exhibit altitudes ranging from 800 to 1,200 metres above sea level, highlighting the varied topographic structure within this portion of the basin.

Table 1. Altitudinal analysis and percentage of topographic units of the basin

Zone	Altitude (m)	Surface area covered (km^2)	% of the basin's relief
Lower M. Valley	<800	750	31.03
Inter. Bafut	800-1200	683	28.26
Upland Bamenda	1201-2600	984	40.71
Total	0-2600	2417	100

Source: Adapted from ASTER, USGS, (2023)

The surrounding highlands form an extension corridor of the Menchum River Basin's wetlands, particularly between Tingoh and Bangwe. The combination of lowlands and encircling highlands accounts for the diversity of crops cultivated within the Lower Menchum Valley agro-zone. The intermediate agro-zone of Bafut, located to the south of the Lower Menchum Valley, lies at an altitude between 800 and 1,200 metres above sea level and includes areas such as Nchum, Bukari, Mankwi, Agyati, Akosia, and Mbebili. This zone covers a surface area of 683 km², representing approximately 28.26% of the basin's total area. The upper zone of the basin, known as Upland Bamenda, ranges in elevation from 1,201 to 2,600 metres above sea level and encompasses parts of Mendakwe, Nkwen, and Mankon. This highland agro-zone constitutes 984 km², accounting for 40.71% of the total surface area of the Menchum River Basin.

Overall, altitudinal analysis shows that the basin consists of 31.03% lowlands, 28.26% intermediate slopes, and 40.71% highlands. Although the highlands form the largest proportion, the combined intermediate and lowland areas (59.29%) offer more favourable conditions for agricultural activity. Even within the upland agro-zones of Bamenda, the presence of wetlands supports agricultural expansion. Consequently, the physiographic diversity of the basin contributes significantly to its land production potential. The types of soils found in these agro-zones reflect the topographic units and play a vital role in influencing agricultural dynamics. Soil characteristics vary across the basin, as illustrated in Figure 3. In the south-eastern part of the basin near the Bamenda escarpment, humid ferralitic soils are prevalent. These soils retain water, but the steep terrain restricts agricultural practices. Some of these soils are also found in the crystalline Nkwen-Mankon area, particularly in wetlands. Most of the basin's humid soils, however, are concentrated in the Lower Menchum Valley, where hydromorphic conditions dominate. The wetlands along the Tingoh-Bangwe axis are rich in alluvial soils, which result from sediment deposits carried down from the surrounding highlands and redistributed by the River Menchum when it overflows its banks. These fertile soils make the zone particularly suitable for intensive agriculture.

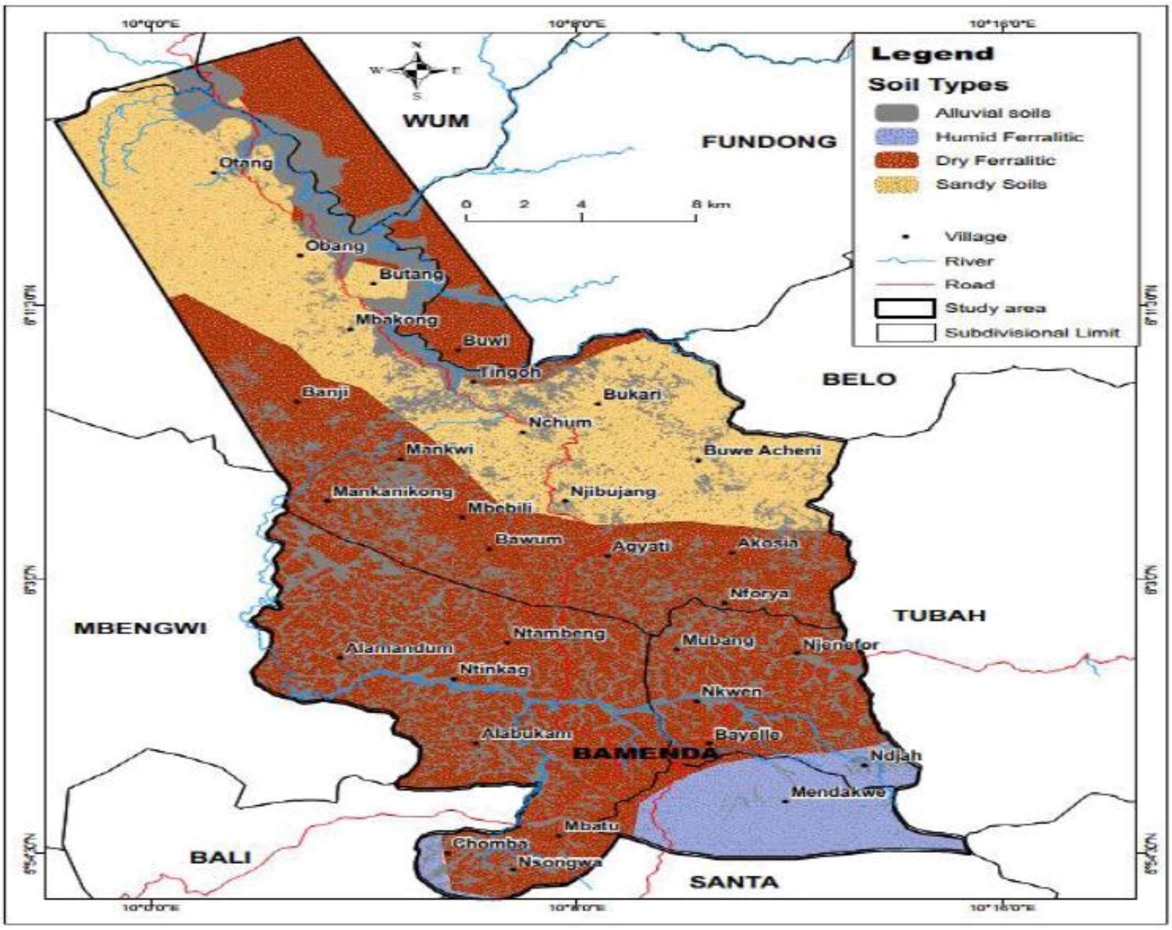

Figure 3. Variation of soil types in the Menchum River Basin

Source: Arc.GIS and ASTER, (2024)

The alluvial soils in the Menchum River Basin constitute a significant land production potential for agricultural development, owing to their high fertility which supports the cultivation of seasonal crops. In contrast, much of the intermediate slopes of Bafut and the crystalline zones of Nkwen-Mankon are characterised by sandy and dry ferralitic soils. These soil types support agricultural activities primarily during the rainy season, due to their limited moisture retention. Overall, the physiographic potentials of the basin, particularly the influence of topographic variation and soil characteristics, serve as critical catalysts for agricultural development within the region.

4.1.2 Topographic and Soil Control Potentials on Spatial Agricultural Dynamics

Considering the spatio-temporal dynamics of agricultural activities in the Menchum River Basin, the paper examined the actual spatial distribution of farmlands throughout the basin. This spatial assessment also took into account the land's productive potential, its agricultural suitability, and farmers' satisfaction with the location of their farmlands within the defined agro-zones. Figure 4 illustrates the percentage distribution of the spatio-temporal location of farmlands across the three main agro-zones of the Menchum River Basin.

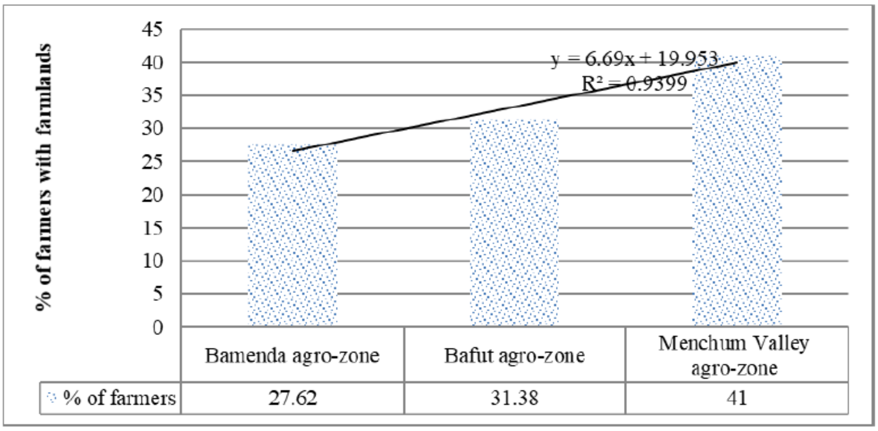

Figure 4. Percentage of farmlands location in the Menchum River Basin

Source: Field work, (2024)

The results presented in Figure 4 indicate that 27.62% of farmers reported their farmlands to be situated in the Bamenda agro-zone. Similarly, 31.38% stated that their farms are located within the Bafut agro-zone, while the majority, 41.0%, revealed that their farmlands lie in the Lower Menchum Valley. However, the precise location of individual farms within these agro-zones demonstrates a spatial distribution, with farmlands found across lowlands, steep slopes, and river valleys. The topographic nature of the basin significantly influences this spatial and temporal variation in agricultural activity. As illustrated in Figure 5, the terrain plays a crucial role in determining where farming occurs and how agricultural practices vary over time across the Menchum River Basin.

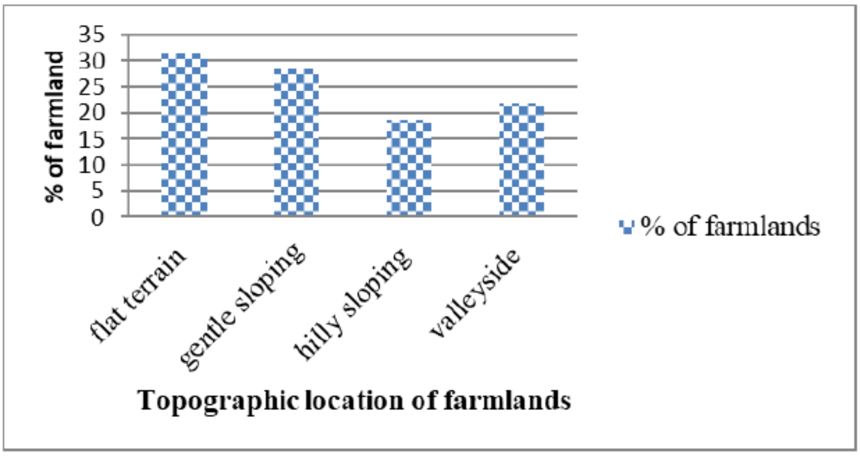

Figure 5. Topographic location of farmlands in the Bamenda Agro-zone

Source: Field work, (2024)

The results presented in Figure 5 indicate that 31.34% of the farmlands in the Bamenda agro-zone are situated on flat terrain, while 28.36% are located on gently sloping land. Additionally, 18.66% of the farmers' farmlands are found in hilly areas, and 21.34% are located along valley sides within the agro-zone.

Findings, however, revealed that nearly all topographic units within the Menchum River Basin have undergone significant agricultural development or activity. In the Bamenda agro-zone, field investigations indicated that the flat areas most intensively used for farming include localities such as Mile 90, Nchubu, Ngongham in Mankon, as well as Mulang, Musang, and Ntasin in Nkwen. The study further revealed that flat terrain in Bafut accounted for approximately 14.81% of farmlands, whereas the Menchum Valley recorded the highest concentration, with 38.27% of farmlands situated on flat terrain (Figure 6).

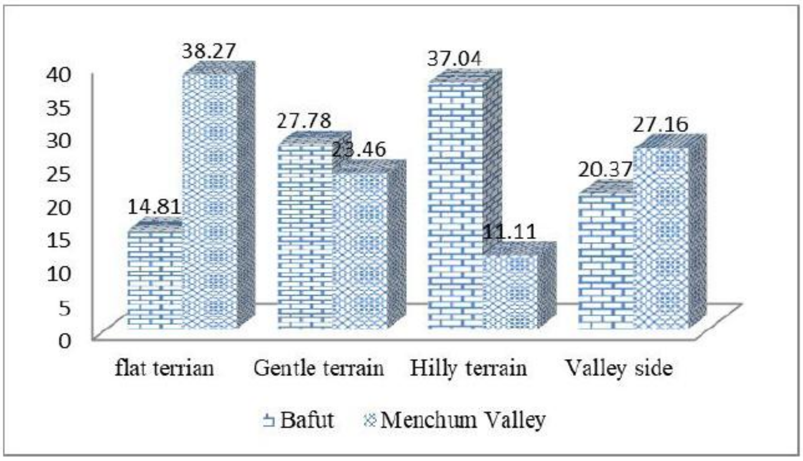

Figure 6. Topography and location of farmlands in the Bafut and Menchum Valley agro-zones of the basin

The high percentage of farmlands in the Menchum Valley is largely attributed to its predominantly flat topography. This offers farmers a significant advantage, enabling them to utilise and cultivate flat land surfaces more effectively for agricultural development. In Bafut, gently sloping terrain accounts for 27.78% of farmlands, while in the Menchum Valley, this figure stands at 23.46%. Field investigations revealed that hilly terrain in Bafut is heavily utilised for farming, comprising approximately 37.04% of the farmland. This is due to the presence of deep valleys and steep slopes, which present challenges to agricultural expansion. In contrast, only 11.11% of farmland in the Menchum Valley is located on hilly terrain. This is likely because the abundance of flat and gently sloping land makes it more favourable for cultivation, discouraging farming on steep slopes. Those who do farm the hilly areas are either adapting to the effects of soil erosion or are compelled by land disputes, as pressure mounts on the more desirable flat and gentle lands.

Within the Bafut agro-zone, numerous valleys separate steep slopes, resulting in 20.37% of farmland being located in valley areas. In the Menchum Valley agro-zone, this figure rises to approximately 27.16%. Farmers take advantage of valley-side farming to benefit from fertile alluvial soils and to practise dry-season irrigation, using nearby rivers and streams to support crop cultivation.

4.1.3 Farmland Dynamics in Relation to Altitude within the Agro-Zones

The altitudinal (vertical) dynamics of farmland distribution across the three agro-zones of the Menchum River Basin as presented on table 2. These dynamics were assessed based on topographic variations derived from ASTER image processing. The results indicate that farmland density generally decreases with increasing altitude. The highest concentration of farmlands was observed in the Lower Menchum Valley agro-zone, while the lowest density was recorded in the upland areas of the Bamenda agro-zone. This reduced farmland density in the upland Bamenda zone can be largely attributed to topographic constraints. Steep slopes in these areas accelerate soil erosion, reduce soil stability, and contribute to soil infertility, factors that significantly hinder agricultural activities. Furthermore, field investigations revealed that urbanisation in Bamenda, coupled with limited availability of cultivable land, has further constrained the expansion of agriculture in the region.

Table 2. Altitudinal analysis and percentage of topographic units of the basin

Altitude (m)	No. of farms (max-min)	Average farm decline (per 100m high)
<800	68-50	18
800-1200	39-30	9
1201-2600	20-15	5

Source: Adapted from ASTER, USGS, (2023)

The results revealed that in the low-altitude zone (below 800 metres), the average decrease in the number of farms per 100-metre rise in elevation was 18. In the mid-altitude range (800-1200 metres), the average decline was 9 farms per 100 metres, while in the high-altitude zone (1201-2600 metres), the average decrease was 5 farms per 100 metres. Field investigations further indicated that farmers exercise discretion in allocating land to specific crop types, largely based on the crop's economic value, whether for commercial purposes or subsistence farming. The dominant crop types cultivated by farmers across the study area are illustrated in Figure 7.

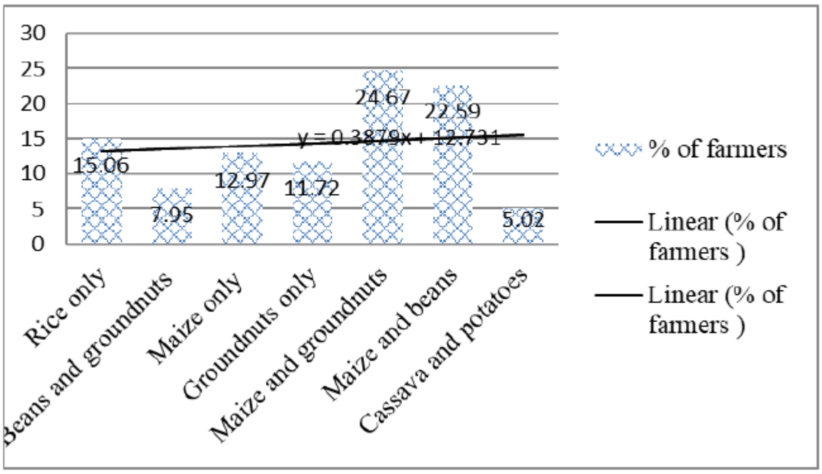

Figure 7. Percentage of farmers cultivating specific crop types on farmlands

Source: Field work, (2024)

Findings indicated that within the Menchum River Basin, 15.06% of farmers cultivate rice exclusively, with the majority of these situated in the Menchum Valley. Rice cultivation is primarily driven by commercial interests, with only a small portion retained for household consumption. Approximately 7.95% of respondents reported cultivating mainly beans and groundnuts, while 12.97% focused solely on maize. Similarly, 11.72% of farmers stated that they grow only groundnuts on their land. A larger proportion, 24.67%, revealed that they primarily cultivate a combination of maize and groundnuts, while 22.59% indicated that their main crops were maize and beans. A small number of farmers reported cultivating cassava and potatoes. Overall, the dominant crops grown in the Menchum River Basin are rice, maize, beans, and groundnuts. The analysis further establishes an inverse relationship between altitude and farmland density across the agro-zones of the basin, suggesting that for every 100-metre rise in elevation, there is a corresponding decline in the extent of cultivated land.

4.2 Discussion

The findings from this paper underscore the significant role of physiographic factors, particularly topography and soil properties, in shaping agricultural dynamics within the Menchum River Basin, Cameroon. These results align with the broader understanding established in the introduction, where studies have demonstrated that natural environmental variables, such as terrain and soil characteristics, are central to agricultural land use, crop distribution, and productivity levels, especially in river basin ecosystems (Chen et al., 2015; Akhtaruzzaman et al., 2014). This discussion connects the findings with previous research, offering insights into how the physical landscape influences farming practices and agricultural outcomes in the Menchum River Basin.

One of the most striking findings of the paper is the influence of topographic segmentation on the spatial distribution of agricultural activities across the Menchum River Basin. The basin's diverse topography, ranging from low-lying alluvial plains in the Lower Menchum Valley to the steep slopes and highlands in Bamenda—dictates where farming can occur and what types of crops are viable. These results are consistent with studies conducted in other regions of Africa, where slope gradients and elevation have been shown to affect soil depth, fertility, and crop types (Tesfaye et al., 2024; Nguyen et al., 2025). The Lower Menchum Valley, with its predominantly flat terrain and fertile alluvial soils, provides highly suitable conditions for agriculture, which is reflected in the high concentration of farmland (41%) in this zone. In contrast, the Bamenda zone, characterized by steep slopes and poor soil stability, faces significant challenges for agricultural expansion. Here, only 27.62% of farmlands are located, and these are largely confined to less fertile, more challenging areas.

The Intermediate Bafut zone offers moderate agricultural potential, where gently sloping land and valley floors provide opportunities for farming. However, the region's topography presents more significant constraints than the lowland areas, resulting in a lower farm density. These findings corroborate the global observation that steep slopes often require specialized farming techniques such as terracing or slope modification to prevent soil erosion and improve land productivity (Chen et al., 2015). In the Menchum River Basin, such practices are inconsistent, with farmers often opting for more accessible, flatter areas, even if they are prone to environmental degradation. This reliance on steep slopes, especially in Bafut, indicates that agricultural practices in the region are not always optimally adapted to the topographic constraints.

Soil properties play a complementary role in shaping agricultural dynamics within the basin. The study reveals that the Lower Menchum Valley is rich in alluvial soils, which are ideal for intensive agriculture, especially rice cultivation. The presence of hydromorphic soils in the wetlands further enhances the agricultural potential of this region. These findings align with studies in other river basins, where alluvial soils, often found in floodplains and river valleys, are highly fertile and support high agricultural productivity (Akhtaruzzaman et al., 2014). The Bamenda and Bafut zones, however, are dominated by ferralitic soils, which have lower moisture retention and fertility, making them less conducive to farming unless the rainy season provides adequate water. This soil contrast highlights the variability in agricultural potential across the basin, with lowland areas being more productive than upland and intermediate zones.

The paper also points to the significant role of soil nutrient redistribution through water flow, especially in the valley areas, where sediment deposition and alluvial soils contribute to soil fertility (Akhtaruzzaman et al., 2014). The Menchum Valley, benefiting from these rich soils and favorable topography, remains the most agriculturally productive zone. In contrast, areas with sandy and dry ferralitic soils in Bafut and Bamenda are less suitable for agriculture, particularly outside the rainy season. These findings reinforce the importance of considering both soil fertility and topographic conditions when evaluating land for agricultural use. The altitudinal analysis reveals a clear relationship between elevation and farmland density, with the highest concentration of farms observed in the Lower Menchum Valley, where altitude is the lowest. This supports the global pattern observed in other agricultural regions, where lower altitudes typically provide more favorable farming conditions (Jaksic et al., 2021). The study found that farmland density decreases with increasing altitude, with the Upland

Bamenda zone having the lowest farmland density. This decrease can be attributed to several factors, including steep slopes, soil erosion, and urbanization pressures in the Bamenda area. The results are consistent with previous studies in highland regions, where increasing altitude generally limits agricultural potential due to the combined effects of erosion, soil infertility, and limited arable land (Nguyen et al., 2025).

Field investigations also highlighted that farming in the Upland Bamenda zone is constrained by steep slopes, which exacerbate soil erosion and reduce soil stability, as observed in other highland regions of Sub-Saharan Africa (Chen et al., 2015). This underlines the need for targeted interventions in the Bamenda zone, such as the promotion of sustainable land management practices to mitigate erosion and enhance soil fertility. The altitudinal dynamics further suggest that farmers in highland areas are more likely to experience land-use conflicts, especially as pressure mounts on the more fertile, lowland areas, a pattern observed globally in rapidly urbanizing regions (Tesfaye et al., 2024).

The findings on crop distribution also underscore the influence of physiographic factors on agricultural practices in the Menchum River Basin. The paper reveals that rice cultivation is concentrated in the Menchum Valley, where the fertile alluvial soils and access to water support this water-intensive crop. The dominance of maize and groundnuts in all agro-zones reflects their adaptability to varying soil and topographic conditions. However, the paper also highlights that crop choices are not always aligned with the physiographic conditions, as evidenced by the cultivation of beans and groundnuts on slopes that may not be well-suited for such crops. This misalignment between crop selection and environmental conditions is a challenge for sustainable agricultural practices in the region and points to the need for better-informed land-use planning and agricultural policies.

5. Conclusion

In conclusion, the findings of this study emphasize the critical role of physiographic factors, topography and soil properties, in shaping agricultural dynamics in the Menchum River Basin. The spatial distribution of agricultural activities, crop types, and farmland density are closely tied to the basin's diverse topography and soil fertility. These results reinforce the importance of integrating physiographic factors into land-use planning to optimize agricultural productivity and sustainability. The paper also highlights the need for more targeted interventions to address the challenges posed by steep slopes and less fertile soils in certain zones, ensuring that farming practices are better aligned with the physical constraints of the land. By incorporating these insights into regional agricultural policies, it is possible to enhance land-use efficiency, reduce ecological degradation, and support sustainable agricultural development in the Menchum River Basin and similar regions in Sub-Saharan Africa.

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