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AGRARIAN LAND MANAGEMENT DYNAMICS AND CROP PRODUCTION: INSIGHTS FROM THE BUI HIGHLANDS OF CAMEROON

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Abstract

The land is an integral identity and the ultimate prerequisite for human survival. It constitutes the agro-resource base with inherent inequalities in the distribution of cropland potentials. The Bui Highlands of Cameroon is a citadel of agrarian resources, with edgy perceptions of ownership entitlements to satisfy land-hungry anxieties on the agrarian landscapes. This study, therefore, aims to examine the impact of agrarian land management on crop production. A survey and comparative research designs were used to obtain primary and secondary data. Questionnaires, interviews, and focus group discussions from 16.9% of the farming population in 504 households were used. Findings revealed that cropland is a major agrarian resource, with inequalities in the distribution and diverse management practices linked to high cropping systems. Cropping indices range from 100-300, with 72% of the population already involved in innovative modern agricultural practices as 90% of households are food secured. Staple crop production anomalies are attributed to climatic shocks and other environmental stressors affecting land-based resources. This indicates a significant increase in the trends of agrarian land management for cropland sustainability, with positive livelihood patterns linked to food security. This calls for the need to improve cropland management security at the grassroots level to safeguard the inextricable link between agrarian resource management and livelihood sustenance in highlands areas.

Keywords: *Bui Highlands, Cropland, Environmental Shocks, Farming Systems, Management*

1. INTRODUCTION

The land is an integral identity and the ultimate prerequisite for human existence in the world. It constitutes agrarian resources where management depicts fundamental components inherent in inequalities in the distribution of cropland potentials. Access to ownership and land management is often problematic in communities that are reliant thereof (Stacey and Henk, 2022). Salient management of agrarian land portrays utmost stakeholders' interaction options (Bailack and Mbanga, 2021) and constitutes indispensable bases for human development in ecumenes of difficult ecological traits (Pambudi, 2021). This is linked to ecological considerations using structural and biological methods to enhance the economic and social status of rural people based on the sustainable exploitation of croplands for livelihoods. This is done through tenure systems regulating the acquisition, ownership, and use of land (Kimengsi *et al.,* 2022).

Agriculture uses 11% of the world's land surface for crop production and managed by multiple actors including Governments, NGOs and international organizations (FAO, 2011; Raymundo *et al.,* 2017). Major trends in agrarian land management have been identified in the developing world, with 70% being agricultural land development by farmers (FAO, 1999; World Bank, 2006). This is established on the main perception of land as the basis of wealth and power (Halling *et al.,* 2020). Such human perceptions anchored on geopolitical consternation, societal civilizations and technologies are hardly unidirectional and in most cases breed management conflicts (Bailack and Fogwe, 2019).

The main strategy in the management of agrarian lands for agricultural production is improving farmer's access to farmlands. This fosters their involvement in the management process to ensure grassroots participation in the exploitation of agrarian resources by local agriculturalists and pastoralists stakeholders (Pierre *et al.,* 2006). The interplay between their management activities and interests reduces intergenerational tensions and conflicts within communities where croplands are a major resource for livelihoods sustenance in socio-ecological systems (Tume, 2018). As pointed out by Mosayeb *et al.,* (2013) rangelands, forest lands and agricultural lands are agrarian rural systems which can be sustainably managed based on the participation of rural stakeholders at different levels. This is based on the precincts of indigenous knowledge perception, where the government safeguards community rights over the common property resources (Bailack and Mbanga, 2021). In this dimension of community participation, efficiency is enhanced in marginal areas where agrarian resources are endemic and exposed to environmental shocks (Samndong and Nhantumbo, 2015).

Multiple agrarian land use options employing cropping systems, livestock production, agroforestry and agro-hydrological management practices related to land tenure are promoted in Cameroon, founded on the top-bottom approach which seems to spare just no single region (Nyanchi and Nchamcham, 2020; Tume, 2018). Such planning signatures are a robust blend of multi-stakeholder, multi-sectorial, institutional and legal frameworks in the management of agrarian systems (Bailack and Fogwe, 2019). In Bui Highlands, agrarian land management for agricultural production is grounded on inequalities in cropland distribution specificities and conflicting claims over agrarian fluid and fuzzy resource boundaries. These geopolitical legacies are prominent on profoundly, with 87% of land management dynamics linked to agrarian landscapes (Bailack, 2022). Management activities have resulted in land use dynamics where individuals, groups, and institutions continually work to satisfy their land hungry anxieties. These interests include land uses on agriculture, watersheds, roads, settlements and grazing among others which are 75% incompatible with each other (Niba *et al.,* 2022; Tume and Asonsaigha, 2019).

Major cropland management trends are seen in agriculture, occupying about 70% of all the land and managed by farmers. A substantial proportion of the livelihood of the population is supported from crop production in terms of food and fodder, nutrition, housing materials, health seeking and food security (Nyanchia and Nchamcham, 2020; Kwei, 2020). There is remarkable unsustainable management of agrarian basin resources. The productivity capacities of some of these basins have significantly declined, depicting negative anomalies, placing livelihoods of the poor farmers at stake. The subsistence rural population in the phase of increasing land tenure insecurities are faced with greater food insecurity and vulnerability (Tume and Magha, 2022). Rising demands for agrarian resources, especially from agricultural land, have resulted in increasing environmental stressors, socio-economic and political tensions (FAO, 2009). These consistencies replicate multiple stakeholders involved and plagued by ills such as land grabbing, illicit use of agrarian resources, seasonal tensions (Fogwe and Sikod, 2014) linked to cropland development and increasing land resource conflicts across Bui.

This study considers croplands as the major agrarian resource exploited in Bui Highlands (Bailack and Mbanga, 2021) which are cultivated ecosystems and agro-productive social systems (FAO, 1999). These are areas under defined crop production systems, with stakeholders affecting and being affected by the management dynamics. The rationale of this study is therefore to seek innovative and sustainable cropland management practices for improved food crop production amidst surging agro-ecological pressures and conflicting land management interests in the highland area. This is established based on existing research gaps where studies have mostly focused on agrarian wetland resources and livestock production (Fogwe and Sikod, 2014) and climatic challenges on food production and security (Tume *et al.,* 2020; Tume, 2018) without considering cropland landscapes and cropping intensities with altitudinal variations. The period before 2010 coincides with the dominance of indigenous practices in cropland management, and from 2010-2022 concurs with innovation diffusion practices in agricultural land management for food security. The study aims to examine the impact of agrarian land management on crop production, based on the premise that the dynamics in agrarian land management through cropland exploitation significantly increases crop production.

2. Materials and Methods

The study was carried in Bui Highlands, in the North West Region of Cameroon. It is located between Latitudes 6°00"-6°20″ North of the Equator and Longitudes 10°30″-11°00″ East of the Greenwich Meridian. The area has an agrarian surface of about 2160.88km^2 with an agricultural population of 598,222 inhabitants as projected to 2022 from the 2005 BUCREP Statistics with an average growth rate of 2.7% each year. Geographically and administratively, Bui Highlands covers six Sub-Divisions with three tribal communities and segmented into six agrarian basins (Table 1). These basins correspond to the seven cropland zones exploited for crop cultivation in this area.

Table 1: Agrarian basin specificities in the Bui Highlands

Major Sub-Division	Farming population	Agrarian basins	Cropland specificities
Jakiri	134826	Jakiri-Wasi-Ber-Mbokam-Ngomrin	Rice, maize, soya beans, groundnuts, oil palm, cassava, cocoa, and coffee.
Kumbo	61569	Nkar-Kumbo-Kikaikom	Maize, cassava, beans, yams, market gardening, solanum potato, and coffee.
Mbiame	130981	Mbiame-Mbonso-Nkuv-Ndzeen	Maize, cassava, beans, yams, coffee, groundnuts, solanum potato, plantains
Nkum	66915	Dzeng-Tatum-Banten-Buh	Market gardening, maize, beans, solanum potato, cocoyams, and coffee.
Noni	152619	Djottin-Nkor-Lassin	Groundnuts, maize, beans, cocoyams, coffee, and plantains.
Oku	51312	Oku-Vekovi-Tadu	Solanum potato, maize, beans, wheat, market gardening, and coffee.
Total	598222	/	/

Source: Field Survey (2020-2022), Tume (2018)

It has diversified geographical characteristics which constitute major components of agrarian lands and crop production systems. It is a mountainous highland area characterised by an orographic plateau within the Cameroon Volcanic Line (CVL). The highland ranges from 710 meters above sea level (masl) from the Mbaw–Tikar Plains to 3,011masl in Mount Oku. Considering that climate is a major driver for the development of croplands in the agrarian basins, the area experiences the highland tropical climate of the Cameroon highland interior type, with rainfall ranging from 2200 mm to 3000 mm (Bailack, 2022). With rainfall and temperature imperatives considered as major agro-ecological determinants of the basins, daily rainfall patterns consist of heavy convectional storms in the afternoons and daily showers common from July to September because of night time condensation. The area has a definite and strong seasonality in rainfall. There have been discrepancies as to the start of the rainy season for the past fifteen years, characterised by inconsistencies on the onset of the first rains. Extreme rainfall episodes (floods and rainstorms) prevail from July to September. The rainfall data collected for Jakiri, Shisong, Tatum, Tobin, Takui, Oku, Takui and Mbonso show that mean annual rainfall ranges from 137.98 mm in Tobin to 179.47 mm in Oku. The mean annual rainfall is 173.06 mm (Shisong), 174.77 mm (Jakiri), 168.03 mm (Tatum), 184.12 mm (Takui) and 160.34 mm (Mbaw Nso) (Tume, 2018). Bui Highlands has a growing population, with 90% of the economic activities linked to land management as a means of livelihood sustenance.

The survey and comparative designs were used to compare the different agrarian land management options and crop production trends from 2000-2022 (22 years). The study was conducted in six Sub-Divisions and six agrarian basins, selected based on field surveys on cropland specificities and stakeholders' management options of the different agrarian lands. The Cropping Intensity Indices for the different basins were calculated using FAO (2009) standards by multiplying the number of crops grown per basin in a year by 100, from where comparisons with field realities were made. This was based on the premise of FAO that the higher the cropping index of a crop, the lower the chances of the exposure of the cropping basin (agrarian basin) to crop loss and food insecurity. A representative sample through the use of a purposive random sampling procedure and sample size was selected from the target population of the study. This was done using Taro (1976) formula for determining the sample size as follows: n= N/1+N (e)2 where n=Sample size; N=Population size; e=Acceptance error. Considering the population, the acceptance error chosen for this study was 0.05. Therefore, the sample size was given as 598222/1+598222 (0.05)2 =2991. This means that the target population considered was 2991 inhabitants.

The study considered 16.9% of the target population as the sample size. Primary data were collected from the field through three complementary techniques involving questionnaires (504), formal and informal interviews and direct observations of management sites of agrarian resources in crop production systems. Focus Group Discussions were conducted with eight farmers' groups' associations and cooperatives across all the basins to get their responses on cropland specificities, management dynamics and cropping intensities as well as resulting impacts from exposure to innovation diffusion on croplands. This was complemented by secondary data obtained from published and unpublished sources in textbooks, websites, dissertations, thesis, journals, periodicals, magazines, laws and administrative texts. Institutions like Palaces, Councils, Civil Society Organisatons and Delegations linked to the management of agrarian lands were consulted. Data was analysed using SPSS Version 20, Arc GIS Version 10.3 and Microsoft Excel 2016.

3. Results

3.1 Spatial distribution of agrarian basins in the Bui Highlands

The distribution of agrarian basins for cropland resources exhibits gross inequality in the Bui Highlands, a mountainous part of the Western Highlands of Cameroon. From the hills of Mount Oku, slopping down to the lowlands of Wasi-Ber-Mbokam-Mbonso-Lasin-Bamti and the valleys of Djottin-Din, are diverse agrarian basins with multiple croplands. These areas with topographic and resource disparities has mainly cropland as a major common property resource. The area is divided into diverse ecological zones portraying physical alterations in climatic elements, soil properties, relief physiognomies, drainage, and vegetation dynamics in the different zones. As such, the quantity and quality of agro-

ecological resources in general and croplands in particular vary, ushering diverse physical and human ecologies, as well as agrarian basins for crop farming systems (Figure 1).

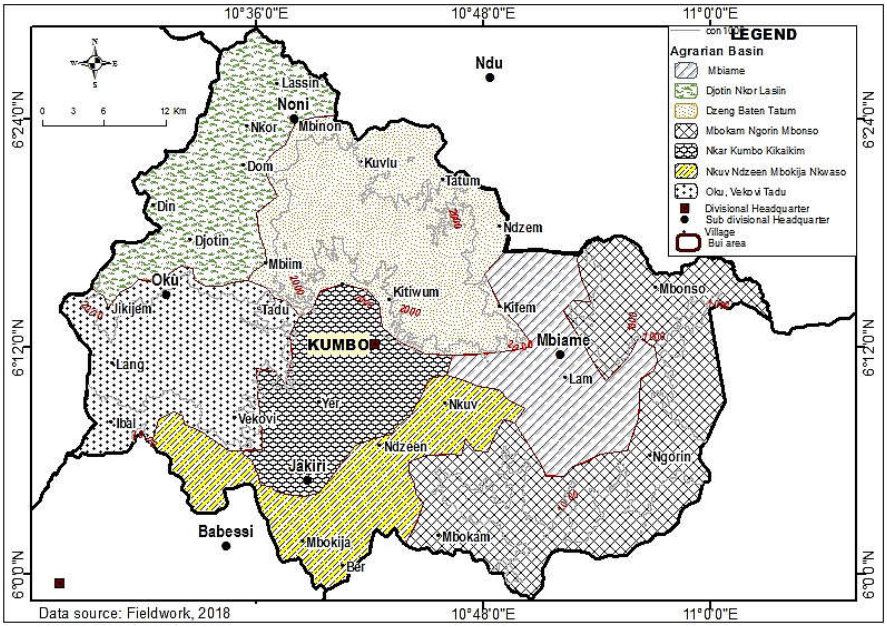

Figure 1: Patterns of agrarian basins in the Bui Highlands

Geographically, Bui is generally a highland area with 36.29% of the landscape ranging from 700-3000+masl. Most of the highlands are concentrated in the agrarian basins found in the Sub-Divisions of Oku, Kumbo and Nkum. Patterns extend from the Oku/Mbessa Highlands and Dzeng-Tatum-Banten-Buh basin, which shares boundaries with Mbiame, and cover the rugged terrain of Yangkitari to the northern extension of the Kov-Ndzeen range in the south-eastern part of Kumbo. The lowlands and plains are mostly found in Mbiame (Mbonso), Noni (Djottin-Nkor-Bamti-Lassin) and Jakiri (Wasi-Ber-Mbokam). This heterogeneous highland is characterised by an archipelago of hills punctuated by river valleys and wetlands in extensive agrarian zones. The area depicts a spectre of a mountainous area stretching from the Bui-Mbim range into the Oku Highlands from the plains of Bamti-Miih ridge to the Baluh-Ngeptang-Nyuiy hills in Dom village. This cuts across to the Vekovi-Wainamah-Jakiri hills, joined by the Dzekwa hills as it stretches to the Takui Highlands and the Dzeng-Mbiame Plateau. This is punctuated by the plain between Mbimsten and Kishong where it is joined by the steep and irregular hills of Nkuv to Lip and Kikaikelaki-Kikaikom-Mbim hills.

The extensive Mbokam-Mbonso area is rich in extensive agrarian lands with low-lying plains as the basis of the croplands of Nkonin, Tiywong, Mbonshari, Lip and Masaan. This is separated by the upper part made up of Rifem, Sancho, Kintsem, Njanawa, Reeh, Lam, Mboshong, Mantum and Shukov. Findings also revealed agrarian resources patterns common in other zones as in the adjacent montane and gallery forest areas rich in young forest soils as the case of Kilum/Ijim-Dom/Enteh, Nkuv-Roh, Tav-Romajai, Koukite-Kovkinkar-Kovifem with numerous agrarian wetlands exploited for cropping lands throughout the different seasons of the year. These landscapes are blessed with diverse agro-ecological resources for crop production, manned by multiple stakeholders with endemic cropland exploitation practices. Such crop lands carpeted by savannah pastures also offer excellent grazing parkland for livestock that often strays into adjacent farmlands as the basis for the management of farmer grazer conflicts rifest in these basins.

3.2 Cropland management systems in the Bui agrarian basins

The management of agrarian lands for crop production is mainly done by farmers, who are the oldest indigenous people in Bui Highlands. Their spheres of operations are around the exploitation of croplands, fertile soils, hydrological and wetland resources. Management activities are based on the rational exploitation and use of land and interests centred on livelihood sustenance. Here, they uphold the custom of respecting their land boundaries and not encroaching into protected lands. Fences, back wires, peace plants, pillar, digging of trenches, and the palanting of fig trees among others are used around their plots for demarcations. This system is however not working in the hollow frontiers where pioneer fronting distorts cropland boundaries, making them controversial and germs of agrarian land resource conflicts. Their management signatures are through the different crop farming systems (intensive and extensive) with patterns portraying variations in the spatial distribution in the different crops cultivated (Figure 2). Topographic units resulting from altitudinal variations and slope gradients give rise to different farming systems across the Bui Highlands. This is attributed to the fact that the variations result in diverse edaphic and climatic environments, which combine to give different crop suitability dimensions for different crop farming systems.

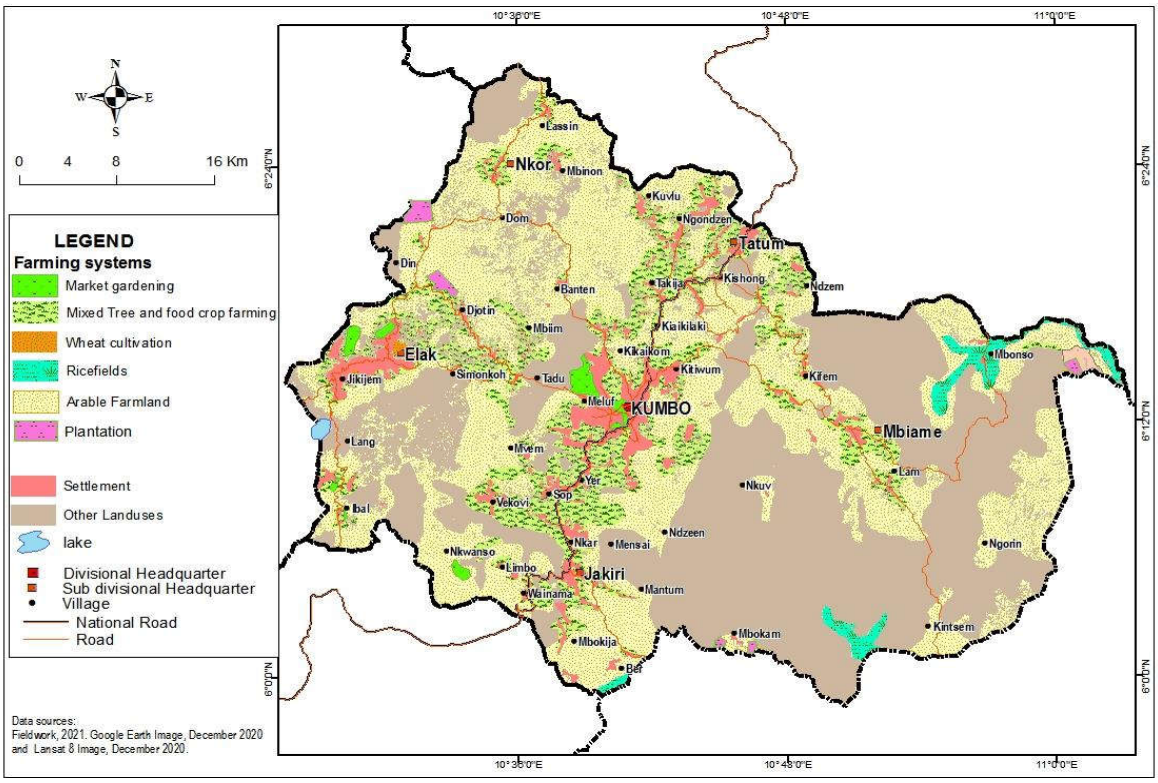

Figure 2: Distribution of cropland management signatures in the Bui Highlands

Mixed cropping is predominant between 1500masl-3000 masl which involves the cultivation of food cops and tree crops with crops like tubers, cereals and cash crops. There is mono-cropping involving market gardening and the cultivation of Irish Potatoes, spices, vegetables, and tomatoes in the adjacent forest communities in Kilum/Ijim, the plains of Bamti, Nkor-Lassin, Mbokam, Mbuluv, Mbonso, Ibal, and Banten. The second classes of mono crops cultivated are cash crops involving the cultivation rice, palm nuts, coffee, wheat, and cocoa in small scales. There are also eucalyptus plantations cultivated in the highlands of Takijah-Mah-Kishong-Buh and Oku.

Smallholder cocoa and rice farming is gaining grounds in the lowlands of Mbonso, Mbokam, Bamti and Lassin, as well as smallholder schemes of wheat cultivation in Oku. In very steep slopes, traditional contour ploughing and terracing is used. Traditional irrigation systems to harness water for agriculture for the sustainability of wetlands for all year-round crop cultivation is common, where gardening is mostly carried out in the dry season. Generally, there is mixed farming in all the agrarian basins, plantation agriculture in low-lying plains, market gardening in the plains, wetlands, and gentle slopes of mount Kilum/Ijim as well as extensive cereal cultivation with innovations in wheat and cocoa cultivation. There are multiple farming practices linked to crop farming systems. The practices are in varied intensities measured in the Linkert Scale. (Table 2).

Table 2: Agrarian system practices in cropland management in the Bui Highlands

Farming system activity	Intensity of practice		
	High	Moderate	Low
Market gardening		✓	
Plantation farming			✓
Animal rearing		✓	
Irrigation			✓
Mixed cropping	✓		
‘Ankara’ (slash & burn)	✓		
Clearing with fire	✓		
Using chemicals		✓	
Mono-cropping			✓
Relay cropping		✓	

The farming system practices vary with traditional systems mostly common in indigenous communities, where management of croplands is based on customs and traditions against modern productive methods. The different practices according to the perception of the people results in variations in the cropping intensities in the different basins with multiple altitudinal zonations (Table 3).

Table 3: Zonal variations in cropping intensity in the Bui Highlands

Agrarian basins	Average farm size	Altitudinal variation	Crop farming systems specificities	Cropping times per year	Cropping index
Mbokam-Ngomrin-Mbonso	3-5 ha	700-1000 masl	Rice, maize, soya beans, groundnuts, oil palm, cassava, cocoa, and coffee.	1	100
Oku-Vekovi-Tadu	1-2 ha	1500-3000 masl	Solanum potato, maize, beans, wheat, market gardening, and coffee.	3	300
Dzeng-Tatum-Banten-Buh	2-4 ha	2000-2500 masl	Market gardening, maize, beans, solanum potato, and cocoyams.	3	300
Djottin-Nkor-Lassin	1-3 ha	1000-1500 masl	Groundnuts, maize, beans, coffee, oil palms, and cocoa.	2	200
Nkar-Kumbo-Kikaikom	<1 ha	1500-2000 masl	Maize, cassava, beans, yams, market gardening, solanum potato, and coffee.	2-3	100-300
Mbiame-Nkuv-Ndzeen	3-4 ha	700-2000 masl	Maize, cassava, beans, yams, cow pea, groundnuts, solanum potato, and plantains.	2	200

The calculations of the cropping intensities are done by multiplying the number of crops grown in a field in a year by 100 (FAO, 2009). This means that if a crop is grown once, the cropping intensity is 100. The higher the cropping index of a crop, the lower the chances of the exposure of croplands to crop loss and food insecurity. The various agrarian zones have varied farm sizes and cropping indices. Farm sizes also vary in the different croplands. The crops cultivated vary in number as determined by the altitudinal variations and farm sizes ranging from less than 1 hectare per person to 5 hectares. More of tree and cash crops are cultivated in lower altitudes while cereals, tubers, and market gardening are more cultivated in mid and high altitudes especially on adjacent montane forest lands with fertile volcanic and young forest soils. This shows a positive relationship between geo-climatic bearings and cropping systems in the Bui Highlands. Cropping indices are high for market gardening and tubers than tree and cash crops. Areas in lower altitudes, where tubers are cultivated like Mbokam-Ngomrin-Mbonso and Djottin-Nkor-Lassin have higher indices. This is linked to a conducive warm-wet climate and fertile alluvial soils that permit all year-round cultivation. Cropping intensities therefore increase with management dynamics, incorporating modern farming processes like fencing, land preparation, clearing, tilling, mulching, planting, fertilizing and other chemical applications, and integrated use of manuring.

Practices of controlling soil erosion and increasing soil humus and nutrients are used. This is done with compost manure gotten from the decomposed animal dung and litter from the Kilum/Ijim montane forest ecosystem in Oku, Kovkikar and Rovitanti in Mbiame and the buffer zones Dom-Enteh Forest reserves. During periods of soil moisture deficiency in the dry season, the rivers, and streams are artificially channeled into dry lands as seen in Mbonso, Simonkoh, Mbokenghas, Tankiy, Ichim, Ibal, Manchok, Jakiri, Vekovi, Romajai, Kai, Ngondzen and Mbiim, Mbokam, Kumbo and Tatum where gardening is highly practiced in the dry season.

3.3 Innovation diffusion and cropland management in the Bui Highlands

Innovations in cropland management have been tilted towards the improvement of soil fertility and increasing crop productivity. On the dimension of soil fertility, chemical fertiliser usage and the use of animal droppings have been highly practiced by the population. For crop productivity, significant increase has been seen in cash crop cultivation and market gardening intensification. All the farmland management processes from land preparation to crop harvest has been modernised since 2010 (Table 4). Smallholder schemes in plantation agriculture have been predominant and crop species like wheat (Fon Sentieh II Wheat Scheme in Oku), cocoa (Mbokam, Nkuv and Kov Ndzeen) and palms in Mbam and Mbiame gaining more grounds across the highland area. The rates of diffusion of farming innovation have been very high in this area. These qualitative dimensions of innovation diffusion show 72% of the population already involved in innovative modern agricultural practices.

Table 4: Dynamics in cropland innovations in the Bui Highlands

Dimensions	Practice before innovation (before 2010)	Practice after innovation diffusion (after 2010 to present)
Farming	Traditional farming	Modern farming
Farmland preparation	Slash, burn & Ankara	Herbicide utilisation, slash & mulch
Farming tools	Sticks, machetes, axes, hoes & diggers	Sprayers, cutlasses, tractors, water pumps, watering cans
Cropping systems	Subsistence (rotational bush fallowing & shifting cultivation)	Intensive cultivation on fixed land (market gardening), mixed and mono-cropping, agro-forestry practices
Types of seeds	Indigenous traditional seeds, irregular planting of seeds, untreated seeds, resistant seeds	High Yielding variety seeds, seed nurseries, vegetative propagation, regular spacing in planting, treated seeds, less resistant seeds
Farm manuring	Organic manure, fallowing, less use of fertilisers	Compost & chemical fertilisers, animal dung
Water supply	Rain fed	Rain fed, watering with cans, buckets, sprinklers, water pumps, irrigation
Crop management	No treatment in farms, longer growth periods, demands much labour, personal funds	Use of pesticides to spray and kill pests, constant crop treatment, shorter growing periods, less labour, group financing, farm loans, support with inputs
Output	No treatment before storage, longer storage periods, good taste, smaller grain size, stored in locally made bans	More, treated before storage, shorter storage periods, less tasteful, larger grain sizes, modern barns & storage facilities

These are mostly reflected in varying new farmland management techniques dominating the indigenous practices (Table 5). Most of the farmlands instead of being cleared and burned before tilling are now sprayed with herbicides. The crops are planted at measured equi-distances instead of random planting. The plants are managed by using insecticides as a means of pest management.

Table 5: Spatial changing agrarian practices in the Bui Highlands

Variables	Agrarian basins percentages (%)						
	Nkar	Dzeng	Nkuv	Mbokam	Nkor	Oku	Mbiame
Changed planting dates	83.9	93.3	80.8	82.4	66.7	96.2	85.9
Zero-tillage	51.6	38.9	94.5	57.4	4.7	65.7	22.4
Organic manure	88.2	78.9	53.4	63.2	96.3	96.2	68.2
Crop residue	89.2	62.2	68.5	35.3	70.4	89.5	56.5
Weed control	66.7	70	100	44.1	80.2	75.2	76.5
Burning	40.9	43.3	87.7	23.5	100	45.7	65.9
Chemical fertilizers	58.1	76.7	90.4	32.4	33.3	65.7	61.2
Agro-forestry	65.6	68.9	20.5	35.3	72.8	82.9	37.6
Animal husbandry	76.3	63.3	23.3	37.9	96.3	48.6	34.1

This has greatly improved the management of croplands and production outputs. Other practices include retention of more crop residue on farms, local weed control techniques, burning of some crop residue, application of chemical fertilizers, agroforestry, and integrated cropping systems with animal husbandry. Of all these strategies, zero-tillage is yet to gain higher practice in all the agricultural basins, except the Nkuv-Gwarkang frontier.

3.4 Management implications on crop production in the Bui Highlands

The management dynamics of agrarian basins through cropland exploitation in the Bui Highlands have bestowed different crop production trends and patterns. This is reflected on the various dimensions of sustainability and optimistic socio-economic outcomes as positive impacts of cropland development. Major crop output produced from 2000-2022 show significant increase, but the slight drop from 2012-2022 is blamed on environmental and socio-political stressors in agrarian zones (Figure 3).

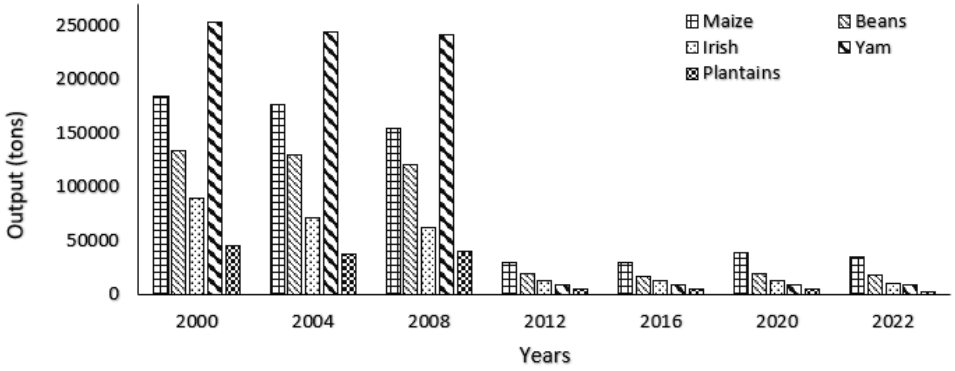

Figure 3: Output trends in major crops produced in the Bui Highlands
Source: MINADER Reports, Bui (2000-2022)

Considering all the management activities, there are spatio-temporal variations in crop production reflected in output statistics. There have been some general fluctuations in crop productions in Bui the Highlands. The fluctuating trends from 2000-2022 are explained by the climate and environmental stressor occurrences that cause challenges to crop production patterns. However, staple crops like maize, beans, and solanum potato have been slowly declining linked to farmers' involvement in its cultivation for daily home consumption. Such combined influences lead to a variety of contrasted effects on crop production, depending upon the type, agrarian zone and the level of adaptation to shocks as computed from farmers' perceptions recorded on changing crop patterns (Figure 4).

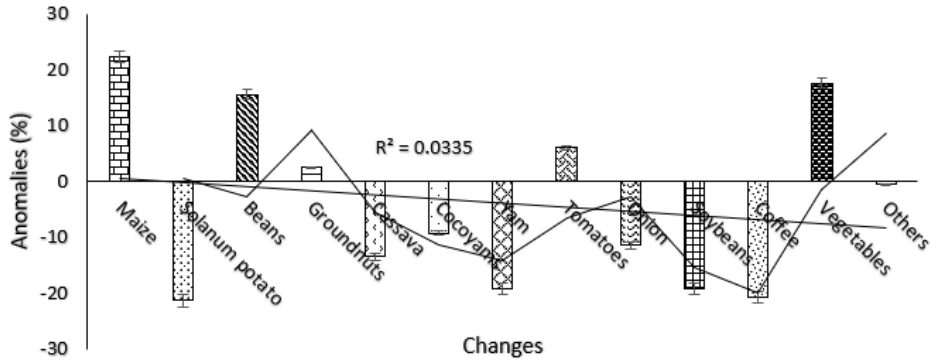

Figure 4: Trends in perceived crop variation anomalies in the Bui Highlands

These negative changes on cassava (-13.4%), coco yams (-9.2%), yam (-19.2%), onion (-11.4%), soybeans (-19.2%), plantain, cow pea, and *egussi* (-0.5%) are attributed to changing climatic and environmental challenges with crops are often attacked by blight and other pathogens during the tender growth stages, leading to plant mortality. Since the growing season of 2016, solanum potato, yam and soya beans have been devastated by blight. Irregular onset of rainfall has also negatively influenced coffee production. The socio-political have also displaced farmers, threatening production activities.

3.5 Cropland management and food security

Assessing the link between the management of croplands and food security designates positive outcomes in all dimensions despite the declining trends of some crop outputs. This stems from reconciling cropland conservation and food security indices, as well as dimensions. Cropping intensities indicate multiple crops being cultivated to condense the challenges in maintaining agrarian land conservation and at the same time ensuring food security (Table 6).

Table 6: Institutional dynamics in cropland management and food security dimensions

Stakeholders/ Institutions	Management activities	Dimensions of food security
Delegations of MINADER	Training of farmers on good farming methods and the use of inputs and high-yielding species & food processing	Availability & utilisation
Councils	Training of farmers on new methods of farming, innovative hybrid seeds and inputs	Availability
	Granting of farm tools to farmers through Agric Shows	Availability
	Construction of roads to link farming areas	Accessibility
	Provision of employment to the population	accessibility
	Construction of markets	Accessibility/affordability
Delegations of MINEPIA	Training farmers on the use of high yielding animals and inputs and meat & dairy products processing	Availability & utilisation
DOs/SDO	Implementation of tenure laws	Availability
NGOs & CIGs	Teaching of farmers on agro forestry, the use of improved seeds and education of farmers on better farming techniques, sale of improved seeds, food aid and training of farmers on methods of agricultural intensification, food aid	Availability, accessibility, affordability & utilisation
Traditional authorities	Rebuilding of peaceful coexistence among tribes, reduction in the number of county Sundays, respect of country Sunday	Availability & accessibility
Population	Food crop production & processing	Availability, accessibility & utilization

Institutions are highly involved in food security in the dimension of availability and accessibility. All the farmers in Bui are involved in food crop production for their households. The fertile soils have been providing sufficient output for home consumption to more than 90% of households having food throughout the year. This indicates that there is the availability of sufficient quantities of food for domestic consumption. According to the statistics from the Elak Council (2021), 80% of the population have two meals a day as of 2010; 60% of the farmers since 2005 increasing their yields by 5%; 20% of farmers practicing sustainable farming; 20% reduction in crop loss; 70% use of improved seeds; 50% use organic manure and 60% farming groups functioning well. Results also indicate 95% of the population having access to food physically and financially, as food crop availability reduces food prices in daily and weekly markets. This corroborates the dimension of accessibility as incomes from resource exploitation ensure access to appropriate food through home production, buying, gifts, borrowing, and food aid. Food products processed from rice, maize, sweet potatoes and cassava increases food availability. Livestock products like meat and milk are used by the population for household consumption. They are also a source of protein and income to the population and increase food security options. This concurs with the dimension of utilisation as food is approximately used through food processing and storage practices. Adequate knowledge and application of nutrition and healthcare services are also used. Resources exploited like forest reserves are also a typical source of rural alternative livelihoods for inhabitants of the adjacent forest communities.

3.6 Constraints to agrarian land management and crop production in the Bui Highlands

Agrarian land management dynamics and crop production in the Bui Highlands is constrained by a multiplicity of anthropogenic and environmental shocks. The onset of political crises in Anglophone Cameroon in 2016 has led to massive displacements in farming communities in all the agro-ecological basins. This has resulted to a drop in crop production and a complete breakdown of other socio-economic livelihood systems linked to land-based resources. In addition, the state of the natural environment is increasingly unfriendly for agriculture, especially on steep slopes and grassland areas. Declining rainfall, floods and recurrent agro-meteorological droughts have been recorded in all the production basins (Table 7).

Table 7: Environmental shocks to agricultural production in the Bui Highlands

Agrarian basins	Environmental shocks
Jakiri-Wasi-Ber-Mbokam-Ngomrin	Declining rainfall, floods, agro-meteorological droughts, invasive species
Nkar-Kumbo-Kikaikom	Agro-meteorological droughts, invasive species
Mbiame-Mbonso-Nkuv-Ndzeen	Agro-meteorological droughts, bush fires, landslides, invasive species
Dzeng-Tatum-Banten-Buh	Agro-meteorological droughts, bush fires, landslides, invasive species
Djottin-Nkor-Lassin	Agro-meteorological droughts, invasive species
Oku-Vekovi-Tadu	Landslides, bush fires, agro-meteorological droughts, invasive species

Dry season fires, the invasion of arable land by bracken fern and bokassa are complicating production systems. In addition, vast areas of the landscape in Bui are occupied by eucalyptus plantations, which are not friendly to crop farms and water sources sustainability.

4. Discussion

There have been inequalities in the distribution of agrarian resource hubs evident in cropland production variations echoed in the study of Bailack (2022). Field evidence portrays patterns distributed in highlands, lowlands, and wetlands. This is linked to diverse agro-ecological zones portraying variations in climatic elements, soil properties, relief, drainage, and vegetation as major determinants of the physical and human ecologies for cropland management dynamics. This is supported by the analysis of Tume (2018); FAO (1999); FAO (2021) that hydro-geomorphological, climatic and edaphic factors are the ultimate determinants of the distribution of agro-ecological zones in rain-fed agricultural systems. The management of these croplands for crop production is mainly done by farmers as the major stakeholders reflected in diverse crop farming systems. This is founded on the fact that cropland is the major resource exploited in agrarian basins. This is consistent with FAO (2011) report positing that agricultural development uses 11% of the world's agrarian land surface for crop production and management by multiple actors.

The results, however, deviate from the study of Fogwe and Sikod (2014) who explained that the major resources exploited in the agrarian wetlands of the Bali-Nyonga Basin are agrarian pastures for livestock production. This is explained by the fact that the study did not factor in the role of croplands in agrarian resource utilization. Findings also reveal a positive relationship between cropping systems and cropping intensities as high cropping indices are seen in market gardening and tubers than tree and cash crops as resonated by FAO (2009). Innovation diffusion patterns exist with the increasing switch from traditional crop production to modern systems (FAO, 2021; MINADER, 2022). This has ushered in optimistic signatures in the productivity of these croplands with the protrusion of intensive farming systems (Nyanchi and Nchamcham, 2020), increasing crop production trends (Tume *et al.,*2020) and food security with 95% of the population having access to food (FAO, 2009; Kwei, 2020). The ultimate outcome has reconciled the sustainability of agrarian resources and ever-increasing livelihood anxieties of indigenous communities linked to cropland exploitation, as remarked by Stacey and Henk (2022); Bailack (2022); Mbanga and Bailack (2021); World Bank (2006).

From another perspective, Mairomi *et al.* (2022) in a study on land use/land cover dynamics in pioneer fronts Nkuh and Nkuv and implications on livelihoods revealed that small agro-plantations are the major land-use changes from the existing rangelands and remnants of natural forests. Farmers have migrated and settled in pioneer fronts, practising agriculture through expansion, stabilization, and consolidation. Diversification and adoption of new techniques like agroforestry, agro-plantations (oil palms, fruit trees, cocoa) is growing among farmers, especially return migrants, bureaucrats and land-use change/land-use practices have significant implications for livelihood improvement for the population (Nyanchi and Nchamcham, 2020).

Agrarian communities across the Bui Highlands are facing multiple shocks and stresses from anthropogenic (Niba *et al.,* 2022), climate variability and other environmental issues (Tume and Maghah, 2021; Tume and Nyuyfoni, 2021). These shocks and stresses are multiplied by the added pressures of unplanned development, leaving many residents without access to basic risk-reducing infrastructure and services, ranging from food security, adequate potable water, housing, and healthcare (Bailack 2022; Kimengsi *et al.,* 2022). This infrastructural deficit and the failures in local governance enhances the underlying vulnerability of local populations to the impacts of climate change in the context of decentralisation. Currently, there is no strategy on how to address adaptation of crop production systems to changing environmental conditions and socio-political shocks in the long term. Increasing investments and financing in Bui is not available in any key agricultural and environmental sector (Kwei, 2020).

Paradoxically, there is no single government institution currently reaching out to all the relevant sectors and stakeholders in strategic partnerships for agricultural development (Tume and Fogwe, 2018; Tume *et al.,* 2019; Tume and Kimengsi, 2021). Institutional and individual capacities are weak. Agricultural infrastructure is poor, hampering the operations of the agricultural sector (Tume and Maghah, 2021). Importance is given more to 'misplaced priorities' like office functionality, communication, out of station allowances and other financial benefits, while there are little or no budgetary allocations for pressing environmental problems distressing the agricultural sector (Mbanga and Bailack, 2019; Tume and Maghah, 2021). These difficulties are further exacerbated by limited operational budgets to implement policy action and outreach, leading to a decline in agricultural production.

5. Conclusion

Agricultural land management options are marked by the dynamic trends of cropland exploitation for crop production. Interactive management possibilities are reflected in farming system predispositions based on livelihood sustenance interest of the population. This has resulted in high cropping intensities that vary at spatio-temporal scales, portraying increasing crop production trends from 2000-2012 and slight decline from 2012-2022 attributed to environmental and socio-political stressors. There are positive agrarian management signatures through positive cropland exploitation outcomes apparent in 95% of management implications linked to cropland sustainability and food security. This establishes a significant relationship between the sustainability of agrarian resources and livelihood options in the exploitation of agrarian resources. Considering this intimate nexus, sustainable responsive prospects in agrarian resource

management can be achieved through a robust blend of indigenous and modern innovative cropland exploitation practices. This is feasible in reversing the trends of agrarian resource degradation in the context of multi-stakeholder and multi-sectorial management options and uncoordinated land exploitation anxieties. Such interactive options can foster the sustainability of land management practices in ecumenes of intricate ecological specificities defiant to space occupancy, increasingly exacerbated in highland agro-ecological zones.

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