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Land-Use Efficiency and Cropping-System Diversification as Pathways to Sustainable Agricultural Intensification in a Mining-Affected Landscape: Evidence from Kono District, Sierra Leone Annual Agricultural Survey Report 2024

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Abstract: Sustainable agricultural intensification is increasingly important in areas where agricultural land is constrained by environmental degradation, competing land uses and declining soil resources. Kono District, Sierra Leone, presents a particularly important case because agriculture operates within a landscape historically shaped by extensive mineral extraction and associated land-use pressures. This study assesses agricultural land-use efficiency and cropping-system diversification in Kono District using secondary data from the 2024 Sierra Leone Annual Agricultural Survey (SLAAS), complemented by relevant literature on sustainable intensification and mining-related land degradation. The study employs a descriptive and comparative analytical design. Agricultural land-use efficiency is assessed using a land-utilization ratio based on average planted area relative to average agricultural area, while cropping-system diversification is assessed from the reported shares of pure-stand, mixed and intercropped systems. The analysis shows that Kono has a relatively large agricultural land base but a lower land-utilization ratio than the national average. Its cropping system is also strongly dominated by pure-stand cultivation, while mixed cropping and intercropping together account for a smaller share than the national level. These patterns indicate opportunities for productivity growth through improved management of suitable agricultural land rather than uncontrolled expansion into new land. Mining-related evidence further indicates that degradation, farmland loss and vegetation disturbance have historically affected agricultural landscapes in Kono. The study argues that sustainable intensification should therefore combine rehabilitation of degraded agricultural land, soil fertility management, appropriate cropping-system diversification, improved extension services and market development. The findings provide a district-level evidence base for integrating agricultural development with land restoration and sustainable natural-resource management in Kono District.

Keywords: *Land Use Efficiency, Cropping System Diversification, Sustainable Intensification Services, Mining, Kono District.*

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I. INTRODUCTION

Agriculture remains central to food security, rural livelihoods and economic development across sub-Saharan Africa, but agricultural production increasingly takes place under conditions of land scarcity, environmental degradation, climate variability and competition among alternative land uses. These pressures have strengthened interest in sustainable agricultural intensification, broadly understood as increasing agricultural output while improving or maintaining environmental outcomes and avoiding unnecessary conversion of additional land (Pretty et al., 2011; Pretty & Bharucha, 2014). Sustainable intensification therefore differs from conventional intensification because its objective is not simply to obtain more output through greater use of land, labour or external inputs; rather, it seeks productivity gains that are compatible with long-term ecological and socioeconomic sustainability (Pretty & Bharucha, 2014).

The sustainable-intensification agenda is particularly relevant to African agricultural systems because many smallholder farmers operate within resource-constrained environments where productivity remains below attainable levels while soil degradation, limited access to inputs, weak markets and climate risks constrain agricultural

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transformation (Pretty et al., 2011). Evidence from African farming systems shows that sustainable intensification can involve several pathways, including improved crop varieties, agroforestry, soil and water conservation, integrated pest management, conservation agriculture, livestock integration and diversification of agricultural enterprises (Pretty et al., 2011). The appropriate pathway is therefore expected to depend on local ecological, economic and institutional conditions rather than on a universal technological package.

Cropping-system diversification is one important component of this broader approach. Diversification can occur through mixed cropping, intercropping, crop rotation, integration of crops and livestock, agroforestry and the introduction of additional crops or enterprises. Its importance lies not only in spreading production and income risks but also in its potential contribution to soil fertility, nutrient cycling, pest regulation, biodiversity and resilience. A large synthesis of diversification studies found that agricultural diversification can improve biodiversity, pollination, pest control, nutrient cycling, soil fertility and water regulation without necessarily reducing crop yields, although outcomes vary according to context and management conditions (Tamburini et al., 2020). Evidence from Ethiopia similarly indicates that combinations of sustainable practices involving cropping-system diversification and conservation tillage can improve farm income and influence input use, although labour and gender-related effects need to be considered (Teklewold et al., 2013).

The issue of agricultural land-use efficiency is equally important. The existence of agricultural land does not necessarily mean that all available land is cultivated in a given season or that land is being used productively. Differences between agricultural area and planted area may reflect fallowing, seasonal production systems, land quality, labour constraints, input limitations, accessibility, tenure arrangements or other socioeconomic and ecological factors. Consequently, a difference between agricultural and planted area should not automatically be interpreted as idle or wasted land. Instead, it can be used as a descriptive indicator of the extent to which agricultural land is brought into cultivation during the reference period.

Sierra Leone's agricultural sector operates within these broader challenges. The 2024 Sierra Leone Annual Agricultural Survey (SLAAS) was undertaken within the Agricultural Integrated Survey framework and included a Production Methods and Environment module covering land use, soil management, irrigation, energy use, agroforestry, climate adaptation and other environmental and production practices (Statistics Sierra Leone [Stats SL] & Ministry of Agriculture and Food Security [MAFS], 2024). The survey was designed to generate comparable agricultural statistics at national, regional and district levels and to support evidence-based agricultural planning.

Kono District provides an especially important setting for examining sustainable agricultural intensification. Agriculture in the district exists alongside a long history of diamond and other mineral extraction. Mining has altered land cover and land-use patterns and has been associated with farmland loss, land degradation, vegetation disturbance and changes in local livelihoods. Research on mining-edge communities in Sierra Leone has reported substantial perceptions of land degradation and reduced availability of suitable farmland in Kono mining communities, while also identifying vegetation loss, water-related problems and other environmental disturbances associated with mining activities (Conteh et al., 2020). More recent research on Kono has likewise linked environmental degradation and large-scale diamond mining with reductions in the quantity and quality of land available for farming, although such studies represent separate evidence and should not be conflated with the aggregate agricultural statistics reported by SLAAS (Wilson et al., 2026).

The interaction between mining and agriculture is therefore important for understanding agricultural land-use choices in Kono. Where land has been degraded, removed from agricultural production or subjected to competing uses, agricultural development cannot rely simply on expanding the cultivated frontier. Instead, sustainable intensification requires greater productivity from agriculturally suitable land while simultaneously restoring degraded areas and protecting remaining productive resources. This principle is consistent with the wider sustainable-intensification literature, which emphasizes producing more from existing agricultural resources while avoiding environmental degradation and unnecessary conversion of additional land (Pretty & Bharucha, 2014).

The 2024 SLAAS provides an important opportunity to examine the current agricultural land-use structure of Kono within this context. The survey reports an average agricultural area of 2.9 hectares and an average planted area of 1.9 hectares for Kono, allowing a simple land-utilization indicator to be calculated. It also reports that pure-stand cultivation dominates Kono's cropping systems, while mixed cropping and intercropping account for smaller proportions. These data provide a basis for assessing two related dimensions of sustainable intensification: the extent to which agricultural land is utilized and the extent to which farmers employ diversified cropping systems.

However, the available published SLAAS district tables have important analytical limitations. They provide aggregate district-level statistics rather than household-level observations containing detailed information on production, labour, fertilizer, seed, machinery, capital, costs and output. Consequently, they cannot support a conventional stochastic-frontier, data-envelopment or production-function estimate of technical or economic efficiency. Similarly, the published tables cannot establish a causal relationship between mining and the proportion of agricultural land that was not planted. Mining must therefore be treated as an important contextual land-use pressure supported by independent literature, while the SLAAS statistics are used to describe the current agricultural land-use and cropping-system situation.

Against this background, this study examines land-use efficiency and cropping-system diversification as practical

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pathways for sustainable agricultural intensification in Kono District. The study is important because it connects current agricultural statistics with the wider question of how agriculture can become more productive and resilient in a landscape where agricultural land has historically competed with and been affected by mineral extraction. The study also contributes to the growing need for district-specific agricultural strategies rather than uniform national interventions.

➢ *Objectives of the Study*

The overall aim of the study is to assess agricultural land-use efficiency and cropping-system diversification as pathways to sustainable agricultural intensification in Kono District, Sierra Leone, while considering the implications of mining-related land degradation for agricultural land resources.

- *The Study Seeks to:*

✓ Assess agricultural land-use efficiency in Kono District.
✓ Examine cropping systems and diversification in Kono District.
✓ Assess the implications of mining-related land degradation for agricultural land use in Kono District.
✓ Propose strategies for sustainable agricultural intensification in Kono District.

II. STUDY METHODOLOGY

➢ *Research Design*

The study adopted a descriptive and analytical secondary-data research design. The principal quantitative data source was the 2024 Sierra Leone Annual Agricultural Survey, supplemented by peer-reviewed literature and other published evidence concerning mining-related land degradation and sustainable agricultural intensification.

A secondary-data design was appropriate because the objective was to interpret existing district-level agricultural statistics rather than generate new household observations. The approach also permits comparison between Kono and other districts using a common national statistical framework.

➢ *Study Location*

The study focused on Kono District in the Eastern Region of Sierra Leone. Kono is an agriculturally important district with a long history of diamond mining. Its agricultural landscape is therefore characterized by the interaction of farming, settlement, natural-resource use and mineral extraction.

The mining history of Kono is particularly relevant because research in mining-edge communities has documented land degradation, loss of farmland, vegetation disturbance and other environmental changes associated with mining activities (Conteh et al., 2020). The present study does not, however, assume that every difference between agricultural area and planted area in the SLAAS data is caused by mining.



Fig 1 Map of Siera Leone Showing Kono District.

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➢ *Study population, Sample Frame and Sample Size*

The SLAAS 2024 sampling frame was derived from the 2023 Sierra Leone Listing Survey. The national survey employed a two-stage design in which enumeration areas were selected first and agricultural households or holdings were subsequently selected within the sampled areas.

Kono was represented by 65 enumeration areas, comprising 62 rural and 3 urban enumeration areas, with approximately 10 farming households targeted per enumeration area. The Kono survey design therefore provided a broad district-level representation of agricultural households.

The present research does not treat the approximately 650 targeted Kono households as 650 independent observations because the published district tables do not provide the household-level records required for such an analysis. Instead, the study uses the officially published Kono district estimates.

➢ *Sampling Techniques*

The original SLAAS employed stratified two-stage random sampling. Stratification was used to ensure geographic representation, followed by selection of enumeration areas and agricultural households.

For this secondary-data study, no additional household sampling was undertaken. Kono was selected purposively as the analytical case because of its combination of agricultural activity and long-standing mining-related land-use pressures.

➢ *Data Analysis*

The analysis was deliberately restricted to indicators that can be calculated reliably from the published SLAAS district-level statistics. The study does not estimate technical efficiency, economic efficiency or causal effects because the published data do not contain the necessary household-level production and input variables.

- *Land-Use Ratio*

$$LUR = (APA / AAA) \times 100$$

LUR is the land-utilization ratio; APA is average planted area; AAA is average agricultural area. It measures the share of reported agricultural area planted during the reference period.

- *Apparent Unplanted Area*

$$AUA = AAA - APA$$

AUA is the difference between average agricultural and planted area. It is descriptive and does not identify why the area was not planted.

- *Apparent Unplanted Proportion*

$$AUP = [(AAA - APA) / AAA] \times 100$$

AUP expresses the apparent unplanted area as a percentage of agricultural area.

- *District Comparative Land-Use Ratio*

$$LUR^{d} = (PA^{d} / AA^{d}) \times 100$$

This permits comparison of Kono with other districts using the same published measures.

- *Cropping-System Diversification*

$$DCS = MC + IC$$

DCS is the diversified cropping-system share; MC is mixed cropping and IC is intercropping.

- *Diversification Gap*

$$DG = DCS_{kono} - DCS_{national}$$

A negative value indicates lower diversification in Kono than nationally.

The indicators are interpreted as descriptive measures rather than causal or econometric estimates. A complete efficiency analysis would require household-level information on output, land, labour, seed, fertilizer, pesticides, machinery, capital and production costs.

III. RESULTS AND DISCUSSIONS

This section presents and discusses the findings on agricultural land-use efficiency, cropping-system diversification, and their implications for sustainable agricultural intensification in Kono District. The analysis draws primarily on the 2024 Sierra Leone Annual Agricultural Survey (SLAAS) and compares Kono's indicators with national and district-level patterns. Particular attention is given to the extent of agricultural land utilization, the prevalence of different cropping systems, and the contextual implications of mining-related land degradation for the sustainable use of agricultural resources. The findings are interpreted in relation to the principles of sustainable agricultural intensification and relevant empirical literature.

➢ *Agricultural Land Use in Kono*

This section examines the extent to which agricultural land in Kono District is being utilized for crop production. The analysis compares the average agricultural area and planted area to determine the level of land utilization and the apparent proportion of land not planted.

Table 1 Authors' Calculations from Stats SL & MAFS (2024).

Indicator	Kono District	Sierra Leone
Average agricultural area (ha)	2.9	1.7

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Average planted area (ha)	1.9	1.2
Apparent unplanted area (ha)	1.0	0.5
Land-utilization ratio (%)	65.5	70.6
Apparent unplanted proportion (%)	34.5	29.4

Kono's average agricultural area of 2.9 hectares is substantially above the national average of 1.7 hectares, while its average planted area of 1.9 hectares is also above the national average of 1.2 hectares.

The calculated land-utilization ratio is 65.5% in Kono compared with 70.6% nationally, giving Kono a gap of approximately 5.1 percentage points.

The apparent unplanted area is 1.0 hectare, equivalent to 34.5% of the average agricultural area. This must not be interpreted as permanently idle land because the survey does not identify the reasons for non-planting.

The finding suggests that Kono's challenge is not simply lack of agricultural land. The policy question is why suitable land is not fully utilized and whether productivity can be raised on land already available.

➢ *Cropping Systems and Diversification*

This section assesses the dominant cropping systems practiced in Kono District and the extent to which farmers combine crops through intercropping and mixed cropping. The findings are compared with the national pattern to highlight Kono's level of cropping-system diversification.

Table 2 Authors' Calculations from Stats SL & MAFS (2024).

District	Agricultural area (ha)	Planted area (ha)	LUR (%)
Kailahun	3.2	2.2	68.8
Kenema	1.8	1.2	66.7
Kono	2.9	1.9	65.5
Bombali	1.4	1.0	71.4
Falaba	2.0	1.8	90.0
Koinadugu	0.9	0.7	77.8
Tonkolili	1.5	1.0	66.7
Kambia	0.8	0.4	50.0
Karene	1.2	0.8	66.7
Port Loko	1.2	0.7	58.3
Bo	1.8	1.1	61.1
Bonthe	1.7	1.0	58.8
Moyamba	1.4	1.0	71.4
Pujehun	2.2	1.6	72.7
Western Rural	0.4	0.1	25.0
Sierra Leone	1.7	1.2	70.6

The district comparison shows considerable variation in the relationship between agricultural and planted area. Kono's calculated land-utilization ratio of approximately 65.5% places it below the national average and below several districts, although it remains above some districts such as Kambia, Port Loko, Bonthe, Bo and Western Rural.

An important implication is that agricultural land availability alone does not explain differences in land utilization. For example, Kono has a considerably larger average agricultural area than several districts with lower land-utilization ratios, yet its utilization ratio remains below that of districts such as Falaba, Koinadugu, Bombali and Pujehun. This suggests that land-use intensity is shaped by multiple factors beyond landholding size.

For Kono, these factors may include the physical condition and suitability of agricultural land, access to labour and inputs, production risks, market incentives and the legacy of competing land uses. The available SLAAS data cannot identify the relative contribution of each factor. Further household-level research is therefore required to determine why some agricultural land is not planted and whether the unplanted portion represents fallow land, degraded land or land reserved for other purposes.

➢ *Implications of Mining-Related Land Degradation*

This section discusses mining as an important contextual pressure on agricultural land resources in Kono District. It relates documented evidence of land degradation and farmland loss associated with mining to the broader challenge of maintaining productive and sustainable agricultural land.

Table 3 Authors' Calculations from Stats SL & MAFS (2024).

Cropping system	Kono (%)	Sierra Leone (%)	Difference (percentage points)
Pure stand	86.5	80.0	+6.5
Mixed cropping	12.4	19.1	−6.7

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Intercropping	1.2	0.9	+0.3
Diversified systems	13.6	20.0	−6.4

Government and private interventions form the backbone of livestock sector development, but their effectiveness depends on scale, coordination, and responsiveness to farmer needs. A robust regulatory environment and incentives for private investment would further stimulate competition and innovation in feed, breeding, and veterinary supplies. The data therefore call for a shift from fragmented initiatives to integrated, multi-stakeholder platforms. Pure-stand cultivation dominates Kono, accounting for 86.5% of reported plots, compared with 80.0% nationally. Mixed cropping accounts for 12.4% compared with 19.1% nationally, while intercropping accounts for 1.2%.

Combining mixed cropping and intercropping gives a diversified-cropping share of 13.6% in Kono compared with 20.0% nationally, a 6.4-percentage-point gap.

This indicates relatively limited plot-level diversification. It does not mean that Kono households lack diversity across plots, rotations, livestock or tree crops because the published table does not provide a household-wide diversification index.

The high prevalence of pure stands provides scope for testing appropriate mixed cropping, intercropping, rotations, crop-livestock integration and agroforestry where these systems are agronomically and economically suitable.

Diversification should not be promoted automatically. Evidence indicates potential benefits for ecosystem services, but outcomes depend on local conditions, and labour requirements and gender implications must be considered (Tamburini et al., 2020; Teklewold et al., 2013).

- *Mining-Related Land Degradation and Agricultural Land Use*

Identifying growth potential helps guide policy, investment, and practical interventions for sustainable livestock development.

Kono's agricultural land-use situation needs to be interpreted within its broader land-use history. Mining has been a major economic activity in the district for decades, particularly diamond mining. The environmental implications of mineral extraction have included land disturbance, vegetation loss and changes in the availability and quality of agricultural land.

Evidence from research conducted in mining-edge communities in Sierra Leone reports substantial perceptions of land degradation in Kono and identifies loss of farmland, vegetation disturbance and declining availability of suitable agricultural land among the environmental consequences associated with mining (Conteh et al., 2020). The study also reports that mining-related disturbances have affected local livelihoods and generated land-use conflicts.

More recent evidence focused specifically on Kono similarly reports relationships between environmental degradation, mining and livelihood losses, including reductions in the quantity and quality of land available for farming (Wilson et al., 2026). Such findings reinforce the importance of land rehabilitation and environmental management in areas where mining and agriculture coexist.

However, an important analytical distinction must be maintained. The SLAAS 2024 statistics showing a 2.9-hectare average agricultural area, a 1.9-hectare average planted area and a calculated 34.5% apparent unplanted proportion do not establish that mining caused the apparent unplanted area. The SLAAS district tables do not contain the household-level spatial or historical information required to estimate such a causal relationship.

Consequently, mining is best interpreted in this study as a contextual land-use pressure rather than as a statistically estimated determinant of the SLAAS land-utilization gap.

This distinction strengthens rather than weakens the argument for sustainable intensification. The available evidence suggests that Kono's agricultural development has to occur within a landscape where parts of the land resource have experienced historical disturbance. Sustainable intensification should therefore include not only increased production on suitable land but also restoration and protection of the natural-resource base.

The implication is particularly important because simply expanding cultivation into previously uncultivated areas may reproduce environmental pressures rather than solve the agricultural productivity problem. Sustainable intensification emphasizes increasing production while avoiding adverse environmental effects and unnecessary conversion of additional land (Pretty & Bharucha, 2014). In a mining-affected landscape, this means that agricultural intensification should be accompanied by land rehabilitation, soil restoration, erosion control, water protection and appropriate land-use planning.

IV. CONCLUSION

This study examined agricultural land-use efficiency and cropping-system diversification as pathways to sustainable agricultural intensification in Kono District, Sierra Leone, using evidence from the 2024 Sierra Leone Annual Agricultural Survey and supporting literature. The results indicate that Kono has a relatively large average agricultural land base but a lower calculated land-utilization ratio than the national average. The difference between agricultural and planted area should not be interpreted as wasted or permanently idle land because the available data do not identify the reasons for non-planting. Instead, the finding points to the need for further investigation into land suitability, fallowing, labour, inputs, market incentives, land condition and other constraints.

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The study also found that Kono's cropping system is strongly dominated by pure-stand cultivation, while mixed cropping and intercropping constitute a smaller proportion than the national average. This suggests potential for appropriately designed diversification, although diversification should be based on agronomic suitability, profitability and local farmer preferences rather than treated as an automatic solution.

Mining provides an important contextual dimension. Independent evidence demonstrates that mining-related land degradation and farmland loss have affected parts of Kono, but the SLAAS data do not establish a causal relationship between mining and the district's apparent unplanted area. Sustainable intensification in Kono should therefore combine improved productivity on suitable existing farmland with rehabilitation of degraded land, soil fertility management, appropriate cropping diversification, stronger extension and improved market access. The central policy objective should be more productive agriculture without reproducing the environmental degradation associated with unsustainable land use.

RECOMMENDATION

The findings indicate that improving agricultural performance in Kono requires an integrated approach that combines more efficient use of existing agricultural land with soil restoration, appropriate cropping-system diversification, and measures that address the pressures associated with mining-related land degradation. Accordingly, the following key recommendations are proposed:

- Farmers should be supported with improved planting materials, soil fertility management, extension services, and appropriate technologies to increase productivity without placing additional pressure on already degraded or environmentally sensitive land.
- Government, mining companies, local authorities, and communities should strengthen the reclamation of mining-degraded land and integrate agricultural and mining activities into coordinated land-use planning to protect productive agricultural areas.
- Agricultural extension services should encourage suitable mixed cropping and intercropping systems that improve resource use, strengthen soil health, diversify production, and reduce production risks.
- Farmers should be supported to adopt soil-conservation, organic matter management, erosion-control, and water-management practices to maintain the long-term productivity of agricultural land.
- Kono District should strengthen the collection and regular updating of information on agricultural land, cropping patterns, degraded areas, and changes in land use to support evidence-based agricultural and environmental planning.

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