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Production Structure, Yield Dynamics, and Technical Efficiency of Ginger Farming Systems in Sierra Leone

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Abstract: Ginger production plays an increasingly important role in rural livelihoods in Sierra Leone, yet empirical evidence on its structural characteristics, productivity dynamics, and efficiency performance remains limited. This study examines the production structure, yield determinants, spatial productivity differences, and technical efficiency of ginger farming systems in two major producing districts Kenema and Kailahun. Data were collected from 160 smallholder farmers using a structured questionnaire and analyzed using descriptive statistics, chi-square tests, t-tests, multiple regression, and efficiency analysis. Results indicate a predominantly smallholder system characterized by low educational attainment and small farm sizes averaging one acre, with balanced gender participation. Yield analysis reveals significant spatial variation, with Njaluahun Chiefdom outperforming Nongowa Chiefdom ($t = -5.21$, $p < 0.001$). Regression results show that education, household labor, organic input use, and access to extension services significantly influence productivity. Efficiency analysis further indicates that only 11.2% of farmers operate at full efficiency, while the majority remain below optimal performance, reflecting substantial productivity gaps. Overall, the findings demonstrate that ginger production is constrained more by inefficiencies in resource use and weak knowledge systems than by resource scarcity. Strengthening extension services and promoting efficient input use are therefore critical for unlocking productivity gains and improving smallholder livelihoods.

Keywords: Ginger production, technical efficiency, smallholder farmers, yield dynamics, agriculture systems

INTRODUCTION

Ginger (*Zingiber officinale*) is an economically important spice crop widely cultivated across tropical and subtropical regions for its culinary, medicinal, and industrial uses. Globally, demand for ginger has increased due to its application in food processing, pharmaceuticals, and nutraceutical industries, making it a key high-value crop for smallholder farmers in developing economies [1]. In Sub-Saharan Africa, ginger production is largely dominated by smallholder farmers operating under resource-constrained conditions, characterized by small landholdings, limited mechanization, and dependence on family labor. These structural constraints often lead to low productivity and high variability in output across regions [2,3]. Despite these challenges, ginger remains an important cash crop contributing to rural income diversification and poverty reduction.

Agricultural productivity in smallholder systems is not determined solely by resource availability but also by the efficiency with which farmers combine and utilize inputs. Empirical evidence suggests that differences in agricultural output are strongly influenced by technical efficiency, human capital, and access to institutional support services such as extension systems and credit facilities [4,5]. This implies that improving productivity requires not only expanding input use but also enhancing management efficiency and knowledge systems. Human capital, particularly education, plays a critical role in shaping farmers' ability to adopt improved technologies and respond to agronomic recommendations. Studies have shown that more educated farmers tend to achieve higher productivity due to improved decision-making and better access to information [6]. Similarly, extension services are widely recognized as key institutional mechanisms for transferring knowledge and improving farm-level efficiency in developing agricultural systems [7]. In addition, soil fertility management and input use practices significantly influence crop productivity in tropical farming systems. The use of organic inputs has been associated with improved soil structure, nutrient availability, and long-term sustainability of production systems [8]. However, adoption of such practices remains limited in many smallholder contexts due to knowledge gaps and resource constraints.

Despite the importance of ginger as a high-value crop, empirical studies on its production structure, productivity dynamics, and efficiency performance remain limited in Sierra Leone. Most existing studies focus on general staple crops, leaving a knowledge gap regarding the specific determinants of ginger productivity and the extent of inefficiency within its production systems. Understanding the structure, dynamics, and efficiency of ginger production systems is therefore essential for designing effective interventions aimed at improving productivity and rural livelihoods. This study addresses this gap by examining the socioeconomic structure of ginger farmers, analyzing yield dynamics across production areas, identifying determinants of productivity, and assessing technical efficiency levels among smallholder farmers in Sierra Leone.

RESEARCH METHODOLOGY

Study Area

The study was conducted in two major ginger-producing districts, Kenema and Kailahun, located in the Eastern Province of Sierra Leone. Specifically, data were collected from Njaluahun Chiefdom in Kailahun District and Nongowa Chiefdom in Kenema District. The study area lies within a humid tropical agroecological zone characterized by annual rainfall ranging from 1,800 to 2,500 mm and mean temperatures between 24°C and 30°C, creating favorable conditions for ginger (*Zingiber officinale*) production. Agriculture constitutes the primary livelihood activity in both districts, with ginger serving as a key cash crop among smallholder farmers. However, notable differences exist between the two locations: Njaluahun Chiefdom is relatively more commercially oriented with higher production intensity, whereas Nongowa Chiefdom exhibits more diversified and less intensive farming systems. These contrasting production environments provide a suitable basis for comparative analysis of production structure, productivity dynamics, and technical efficiency in ginger farming systems.

Study Design and Sampling Techniques

A cross-sectional survey design was adopted to collect data from ginger farmers at a single point in time. A multi-stage sampling technique combined with proportionate simple random sampling was used to ensure representativeness and minimize selection bias. In the first stage, Kailahun and Kenema districts were purposively selected based on their prominence in ginger production in Eastern Sierra Leone. In the second stage, Njaluahun and Nongowa chiefdoms were purposively selected due to their high concentration of ginger farmers. In the third stage, ginger-producing communities within each chiefdom were identified with the assistance of agricultural extension officers and farmer-based organizations. In the final stage, respondents were randomly selected from updated farmer lists using proportionate allocation to ensure balanced representation across the two chiefdoms.

Sample Size Determination

The sample size was determined using the Cochran (1977) formula for large populations under maximum variability conditions, which is widely applied in agricultural and social science research:

$$n_0 = \frac{Z^2 p(1-p)}{e^2}$$

Where:

- n_0= required sample size
- Z= Z-value at 95% confidence level (1.96)
- p= estimated proportion of attribute in the population (0.5 assumed for maximum variability)
- e= margin of error (0.08)

Substituting:

$$n_0 = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.08)^2} = \frac{3.8416 \times 0.25}{0.0064} = 150.06 \approx 150$$

To enhance statistical reliability and account for possible non-response, the sample size was adjusted upward, resulting in a final sample of 160 respondents distributed as follows: Njaluahun Chiefdom (66 farmers) and Nongowa Chiefdom (94 farmers).

Data Collection and Analytical Framework

Primary data were collected using a structured questionnaire administered through face-to-face interviews with selected farmers. The questionnaire captured information on socioeconomic characteristics, farm structure, production practices, input use, institutional access, and yield levels measured in bags per acre. The instrument was pre-tested in a nearby ginger-producing community not included in the final sample to ensure clarity, validity, and reliability. Data analysis combined descriptive, inferential, and econometric techniques. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize farmer characteristics. The chi-square test of independence was used to examine associations between categorical variables, specified as

$x^2 = \Sigma[(O - E)^2 / E]$. Differences in mean yield between Njaluahun and Differences in mean yield between Njaluahun and Nongowa chiefdoms were assessed using an independent samples t-test specified as $t = (\bar{X}_1 - \bar{X}_2) / \sqrt{[(s_1^2/n_1) + (s_2^2/n_2)]}$. A multiple linear regression model was used to identify determinants of ginger yield, specified as $Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon_i$, where Y_i represents yield, X_1 land size, X_2 education level, X_3 household labor, X_4 organic input use, and X_5 extension access. Technical efficiency was estimated using a stochastic frontier production function model specified as $Y_i = f(X_i; \beta)\cdot \exp(V_i - U_i)$, where V_i captures random noise and U_i represents non-negative inefficiency effects. Technical efficiency was derived as $TE_i = \exp(-U_i)$, where values closer to 1 indicate higher efficiency.

RESULTS AND DISCUSSION

Production Structure and Socioeconomic Profile of Ginger Farmers

The structural characteristics of ginger farming systems reveal a predominantly smallholder-based, labor-dependent production environment with limited human capital development (Table 1).

Table 1: Socio-Demographic Characteristics of Ginger Farmers

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	81	50.6
	Female	79	49.4
Age Group	20–29 years	11	6.9
	30–39 years	43	26.9
	40–49 years	47	29.4
	50–59 years	45	28.1
	60+ years	14	8.8
Marital Status	Married	143	89.4
	Widowed	12	7.5
	Single	4	2.5
	Divorced	1	0.6
Education Level	None/Informal	73	45.6
	Primary	38	23.8
	Secondary	42	26.3
	Tertiary	7	4.4
Household Size	1 member	2	1.3
	2 members	78	48.8
	3 members	49	30.6
	4+ members	31	19.4
Farm Size (acres)	0.5	1	0.6
	1	105	65.6
	2	39	24.4
	3+	15	9.4

Gender participation is nearly balanced (50.6% male; 49.4% female), indicating that ginger production is not gender-restricted but rather a shared livelihood activity, which has implications for inclusive agricultural interventions. The age distribution is heavily skewed toward economically active but aging cohorts, with approximately 57.5% of farmers falling within the 40–59-year range. In contrast, youth participation (20–29 years) remains critically low (6.9%), suggesting weak generational renewal and potential long-term sustainability concerns in ginger production systems. This demographic pattern reflects structural barriers such as limited access to land, capital, and market incentives for younger farmers.

Educational attainment is notably low, with 45.6% of respondents lacking formal education and only 4.4% attaining tertiary-level education. This indicates restricted cognitive capacity for adoption technology, which directly constrains productivity-enhancing innovations. From a production systems perspective, this reinforces the importance of extension services as substitutes for formal education. Farm structure is highly fragmented, with 65.6% of farmers cultivating approximately one acre. This confirms that ginger production operates within a smallholder subsistence-to-semi-commercial continuum, where economies of scale are minimal and intensification rather than expansion becomes the primary pathway to productivity growth. Household size distribution shows that 79.4% of farmers operate within small to medium households (1–3 members), suggesting limited household labor availability, which may constrain labor-intensive operations such as land preparation, weeding, and harvesting.

Gender-Neutral Structural Patterns in Landholding and Labor Organization

The cross-tabulation results (Tables 2 and 3) provide important insights into the gendered structure of production resources.

Table 2: Farm Size Distribution by Gender of Respondents

Farm Size (acres)	Male	Female	Total	Row %	x^2	p-value	Cramer's V
Small (0.5-1)	52	54	106	66.3			
Medium (2)	21	18	39	24.4			
Large (3-4)	8	7	15	9.4			
Total	81	79	160	100	0.247	0.884	0.039

Table 3: Household Size Distribution by Gender of Respondents

Household Size	Male	Female	Total	Row %	x^2	p-value	Cramer's V
Small (1-2)	43	37	80	50.0			
Medium (3)	23	26	49	30.6			
Large (4+)	15	16	31	19.4			
Total	81	79	160	100	0.659	0.719	0.064

The absence of statistically significant relationships between gender and farm size ($x^2 = 0.247$, $p = 0.884$) indicates that land access is relatively equitable between male and female farmers within the study area. The extremely low Cramer's V (0.039) confirms that gender explains virtually none of the variation in landholding. Similarly, household size distribution is independent of gender ($x^2 = 0.659$, $p = 0.719$), suggesting that labor endowment structures are not gender-differentiated. This is particularly important because it implies that observed productivity differences (if any) are unlikely to be driven by gender-based disparities in structural resources. From a systems perspective, these findings challenge conventional assumptions in Sub-Saharan African agriculture, where gender disparities often dominate access to productive assets. Instead, the results suggest a gender-neutral but resource-constrained production system, where limitations are systemic rather than socially segmented.

Spatial Dynamics of Ginger Productivity

The comparative yield analysis (Table 4) reveals significant spatial heterogeneity in production performance. Farmers in Njaluahun Chiefdom achieve a mean yield of 5.45 bags/acre compared to 4.21 bags/acre in Nongowa Chiefdom, representing a substantial productivity differential of 1.24 bags/acre. This difference is statistically robust ($t = -5.21$, $p < 0.0001$) and associated with a large effect size (Cohen's $d = 0.84$), indicating that the variation is not only statistically significant but also economically meaningful. The non-overlapping confidence intervals further reinforce the reliability of this difference. Such spatial variation suggests that agroecological conditions, input access, management practices, or institutional support systems differ significantly across locations. This highlights the importance of location-specific interventions rather than uniform policy approaches. Njaluahun may represent a best-practice production environment, while Nongowa reflects constraints that limit productivity realization.

Table 4: Yield Comparison Between Nongowa and Njaluahun Chiefdoms

Statistic	Nongowa	Njaluahun	Difference	t-value	df	p-value	Cohen's d
Sample size (n)	95	66	-				
Mean yield (bags/acre)	4.21	5.45	1.24				
Standard deviation	1.63	1.39	-				
Standard error	0.17	0.17	-				
95% Confidence Interval	[3.88–4.54]	[5.11–5.79]	[0.77–1.70]				
Test statistics				-5.21	159	<0.0001	0.84

Determinants of Yield: Input-Output Relationships in Ginger Production

The regression model (Table 5) provides a robust evaluation of the drivers of productivity within ginger farming systems, revealing that yield is primarily influenced by knowledge, labor, and institutional support rather than land expansion. Education level exerts a positive and statistically significant effect on yield ($\beta = 0.211$, $p = 0.011$), confirming that human capital enhances farmers' ability to adopt improved agronomic practices and optimize input use. This finding aligns with the earlier structural observation of low educational attainment, reinforcing the need for targeted knowledge dissemination. Household labor also contributes positively ($\beta = 0.129$, $p = 0.030$), suggesting that labor availability remains a critical production constraint, particularly in smallholder systems where mechanization is limited. The most influential factor is the use of organic inputs ($\beta = 0.783$, $p < 0.001$), which exhibits a strong and highly significant effect on yield. This indicates that soil fertility management is a central determinant of productivity, and that sustainable input use can substantially improve output. Access to extension services ($\beta = 0.641$, $p = 0.001$) also significantly enhances yield, demonstrating the critical role of institutional support in bridging knowledge gaps and improving farm performance. In contrast, land size does not significantly influence yield (ß = 0.118, p = 0.229), indicating that productivity gains are driven by intensification rather than extensification. This is a crucial finding, as it suggests that increasing land area alone is insufficient without improvements in management practices.

Table 5: Determinants of Ginger Yield

Variable	ß Coefficient	Std. Error	t-value	p-value	95% CI
Intercept	2.851	0.347	8.206	<0.001	[2.166, 3.536]
Land size	0.118	0.098	1.207	0.229	[-0.075, 0.311]
Education level	0.211	0.082	2.567	0.011	[0.049, 0.373]
Household labor	0.129	0.059	2.186	0.030	[0.013, 0.245]
Organic input use	0.783	0.197	3.970	<0.001	[0.394, 1.172]
Extension access	0.641	0.199	3.226	0.001	[0.249, 1.033]

Technical Efficiency Distribution and Production Performance

The efficiency results (Table 6) indicate a markedly uneven distribution of technical efficiency across ginger farmers, with only 11.2% operating at the production frontier and achieving full efficiency. Although a further 44.2% of farmers fall within moderate to high efficiency levels (≥0.80), a substantial proportion (55.8%) remains below the efficiency threshold, reflecting widespread underperformance in resource utilization. This pattern points to persistent structural and operational inefficiencies within the production system, which are likely associated with constraints in access to improved inputs, limited technical knowledge, weak extension service delivery, and generally suboptimal farm management practices. These constraints collectively reduce the ability of farmers to transform available inputs into optimal output levels. The observed efficiency distribution therefore suggests that the ginger production system is not constrained primarily by resource scarcity, but rather by inefficiencies in production management. This implies the presence of significant latent productivity potential, whereby a large proportion of farmers could substantially increase output without necessarily expanding land area or input use, provided that efficiency-enhancing interventions are effectively implemented.

Table 6: Technical Efficiency Distribution

Efficiency Score	Interpretation	Frequency	Percentage
1.00	Fully efficient	18	11.2
0.90-0.99	Highly efficient	22	13.7
0.80-0.89	Moderately efficient	31	19.3
0.70-0.79	Moderately inefficient	35	21.7
0.60-0.69	Inefficient	28	17.4
<0.60	Highly inefficient	27	16.8

The stochastic frontier results show that ginger production in the study area is influenced by a mix of productive inputs and a significant level of inefficiency(Table 7). The intercept is positive and highly significant, indicating a strong baseline level of production even after accounting for observable inputs. Among the explanatory variables, land size has a positive but statistically insignificant effect on output, suggesting that expanding farm size alone does not meaningfully improve ginger yield. This implies that land is not being used in a productivity-enhancing way, and increases in area without improvements in management may not translate into higher output. Labour, measured through household size, has a positive and statistically significant effect on ginger yield. This indicates that ginger farming in the study area is labour-intensive, and households with more available labour tend to achieve higher productivity. Similarly, organic inputs have a strong and highly significant positive effect on output and represent the most influential factor in the model. This result shows that improvements in soil fertility management through organic matter application play a critical role in enhancing ginger productivity. Seed quality also has a significant positive effect, meaning that farmers who use better planting materials obtain higher yields, highlighting the importance of seed selection and access to quality planting inputs. Farming experience, however, has a positive but statistically insignificant effect, suggesting that years of experience alone do not necessarily translate into improved productivity, possibly due to limited innovation or weak extension support.

Table 7: Stochastic Frontier Analysis Results (Cobb-Douglas Production Function)

Variable	Coefficient	Std. Error	z-value	p-value
Production Frontier				
Intercept (β_0)	1.524	0.186	8.194	<0.001
Log(Land Size)	0.142	0.089	1.596	0.111
Log(Labor)	0.178	0.058	3.069	0.002
Log(Organic Inputs)	0.415	0.092	4.511	<0.001
Log(Seed Quality)	0.203	0.071	2.859	0.004
Log(Experience)	0.062	0.055	1.127	0.260
Variance Parameters				
σ^2	0.185	0.023	8.043	<0.001
γ	0.682	0.058	11.759	<0.001
λ	1.464	0.112	13.071	<0.001
Model Fit				
Log-likelihood	-94.32			
LR test (γ=0)	$x^2(1) = 58.47$, $p < 0.001$			
Return to Scale	1.001 (Constant returns)			

The variance parameters provide important insight into production inefficiency. The total variance is statistically significant, confirming that variation in ginger output is not random but influenced by inefficiency. The gamma value is 0.682, which indicates that about 68.2% of the variation in output among farmers is due to technical inefficiency rather than random shocks such as weather or measurement errors. This is a strong indication that inefficiency is a major constraint in ginger production. The lambda value of 1.464 further confirms that inefficiency effects dominate random noise, meaning managerial and technical inefficiencies play a greater role than external uncontrollable factors in explaining output differences among farmers. The likelihood ratio test strongly rejects the hypothesis that there is no inefficiency effect, confirming that the stochastic frontier model is appropriate for the data and that ordinary least squares estimation would be insufficient. The return-to-scale value of 1.001 indicates constant returns to scale, meaning that a proportional increase in all inputs leads to an almost equal proportional increase in output. This suggests that farmers operate at an efficient scale of production, but gains in output are more likely to come from improving input efficiency rather than expanding farm size.

Yield Gaps and Potential Productivity Gains

The yield gap analysis (Table 7) provides strong evidence of substantial unrealized production potential across all efficiency cohorts, revealing pronounced disparities between current and optimal output levels. Farmers in the lowest efficiency category (<0.60) exhibit the most severe underperformance, with potential output more than doubling under full efficiency conditions, indicating extensive inefficiencies in resource utilization and production management. Even among moderately inefficient farmers (0.70–0.79), the results show meaningful productivity gains of approximately one-third, demonstrating that efficiency improvements are not limited to the lowest-performing group but are achievable across all production levels. When aggregated, the results show that the average farmer currently produces 18.1 bags of ginger but could potentially reach 27.5 bags if operating at full efficiency, representing an average gain of 9.4 bags per farmer. These patterns clearly indicate that the dominant constraint within the ginger production system is not the scarcity of resources, but rather the inefficient allocation and utilization of existing inputs. The magnitude and consistency of the yield gaps suggest systemic inefficiencies embedded within production practices. Consequently, improving productivity in this system requires targeted interventions focused on strengthening farmers' technical capacity, improving access to productive inputs, and enhancing the effectiveness and reach of agricultural extension services.

Table 8: Yield Gaps and Potential Gains

Efficiency Group	Current Yield (bags)	Potential Yield	Gain	% Increase
Highly inefficient (<0.60)	12.5	25.6	13.1	104.8
Inefficient (0.60–0.69)	18.2	27.1	8.9	48.9
Moderately inefficient (0.70–0.79)	22.1	29.4	7.3	33.0
Overall mean	18.1	27.5	9.4	-

DISCUSSION

The findings of this study provide important empirical evidence on the structure, productivity dynamics, and technical efficiency of ginger production systems in Eastern Sierra Leone. The results indicate that ginger farming is predominantly a smallholder enterprise characterized by limited landholdings, moderate household labor availability, and generally low educational attainment. This structural configuration is consistent with broader patterns in Sub-Saharan African agriculture, where small farm sizes and low human capital constrain productivity growth and technological adoption [2,3]. The near balance in gender participation suggests that ginger production is relatively inclusive, with both men and women actively engaged in production activities. This contrasts with earlier evidence from African agricultural systems where gender disparities in access to productive resources are often pronounced [9]. The implication is that structural constraints in the study area are less gender-based and more related to general resource limitations and institutional access. The observed spatial variation in yield between Njaluahun and Nongowa chiefdoms highlights significant heterogeneity in production performance. Such differences are commonly attributed to variations in agroecological conditions, input accessibility, and institutional support systems such as extension services [10]. The higher yields recorded in Njaluahun suggest comparatively better production conditions or more effective management practices. Similar spatial disparities in agricultural productivity have been widely documented in root and tuber crop systems across West Africa, where differences in knowledge dissemination and input use intensity contribute significantly to yield variation [11].

The econometric results further reveal that ginger productivity is significantly influenced by education, household labor, organic input use, and access to extension services. The positive effect of education supports human capital theory, which argues that education enhances farmers' ability to process information, adopt innovations, and allocate resources more efficiently [12,6]. Similarly, the significance of household labor reflects the labor-intensive nature of ginger production, where most operations rely heavily on family labor due to limited mechanization [13]. The strong effect of organic input use highlights the central role of soil fertility management in sustaining agricultural productivity, particularly in tropical agroecosystems [8]. The significance of extension services further reinforces the importance of institutional support systems in enhancing productivity through knowledge transfer and improved practices [7]. Interestingly, farm size was not a significant determinant of yield, indicating that productivity gains are not driven by land expansion but rather by intensification and improved management practices. This finding aligns with evidence suggesting that increasing land size without improving efficiency does not necessarily lead to higher productivity [14]. The efficiency analysis reveals substantial inefficiencies within the ginger production system, with more than half of the farmers operating below optimal efficiency levels. This is consistent with findings from stochastic frontier studies in developing country agriculture, which report significant efficiency gaps due to weak extension systems, limited access to inputs, and suboptimal management practices [5,15].

The results suggest that ginger productivity is driven more by input quality and management practices than by farm size. The strong and significant effects of organic inputs and seed quality highlight the importance of soil fertility management and access to improved planting materials in enhancing yields. This is consistent with recent evidence showing that productivity gains in smallholder systems increasingly depend on intensification and improved input use rather than land expansion [16, 17]. The insignificant effect of land size implies that simply expanding cultivated area does not improve output unless accompanied by better management practices. Labour remains important, reflecting the labour-intensive nature of ginger production in smallholder systems. Similar studies in Sub-Saharan Africa report that labour and management efficiency remain key determinants of productivity in root and tuber crops [18]. The relatively high inefficiency level indicates that a large share of output variation is due to managerial and technical inefficiencies rather than external factors. This suggests substantial room for productivity improvement through better extension services, input use efficiency, and farm management, as supported by recent efficiency literature [19]. The large yield gaps identified further confirm that inefficiency, rather than resource scarcity, is the primary constraint limiting productivity. Farmers in lower efficiency categories could potentially double their output if operating at full efficiency, indicating substantial latent production potential. This aligns with the broader argument that improving efficiency in smallholder agriculture can generate significant productivity gains without requiring additional land or inputs [4]. Overall, the results demonstrate that agricultural productivity constraints in smallholder systems are largely driven by inefficiencies in resource use and weak institutional support rather than physical resource scarcity alone [12,2].

CONCLUSION

In conclusion, the study demonstrates that productivity in smallholder ginger systems in Eastern Sierra Leone is primarily constrained by inefficiencies in resource use rather than by limitations in land or input availability. The evidence shows that improvements in human capital, access to extension services, and soil fertility management have a far greater impact on output than farm expansion, indicating that intensification, rather than extensification, is the dominant pathway for productivity growth. The substantial efficiency gaps observed across farmers reveal significant latent production potential within the system. This suggests that targeted interventions aimed at improving technical knowledge, strengthening extension delivery, and promoting efficient input use could generate meaningful productivity gains without increasing production costs or resource pressure. Overall, enhancing efficiency within existing production systems offers the most viable and sustainable strategy for improving ginger output and farmer livelihoods.

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