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Original Research Article

Determinants of competitiveness of irrigated and rain-fed tomato production technologies in Ghana

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This paper estimates the competitiveness and the determinants of the competitiveness of tomato farms under irrigated and rainfed technologies from four ecological zones in Ghana. Adopting the PAM model on three-year panel data from 698 tomato farmers, comprising 206 irrigated and 492 rainfed farmers, the paper provides evidence that tomato farms under the two technologies are uncompetitive at the aggregate level, and otherwise at the individual farm level. The study found that access to credit, extension services, yield, fertilizer price, FBO membership, and farmer location have a significant impact on competitiveness. The paper recommends that policymakers prioritize agricultural finance and access to technical and extension services.

Keywords: Competitiveness, tomato, production, irrigation and rained technologies, Ghana

INTRODUCTION

Tomato (*Lycopersicon esculentum Mill*) is an important vegetable in Ghana. The crop is grown in most parts of Ghana, as a 'cash crop' because it helps to alleviate food and cash shortages (Donkoh et al., 2013). Tomato farming is predominantly a small-scale enterprise in Ghana, with a few large-scale initiatives at authorized irrigation locations, and its distribution throughout the year is significantly seasonal (MoFA, 2018).

Data from the Ministry of Food and Agriculture also revealed that Ghana exported about 11,210.7 Mt of tomato products, constituting a total of about Ghana Cedis (GHC)44.04 million in export earnings (GSS, 2018). However, the total import was 67,957.3 Mt of tomato products in the same year, constituting GHC 228.29 million worth of import at customs value (GSS, 2018). This makes Ghana a net importer of tomato products valued at 56,746.6 metric tonnes.

The productivity of tomatoes has also remained relatively low over the last two decades. The average yield was about 7.80Mt/ha in 2018 compared to a global average yield of 34 Mt/ha. The yield of tomatoes in Ghana is also lower than major producing countries in the world, such as Burkina Faso (10 Mt/ha), Ethiopia (15.25 Mt/ha), Netherlands (47.6 Mt/ha), and South Korea (68.21 Mt/ha), (Gemechis et al., 2012; FAOSTAT, 2018). The low yield is attributed to a lack of improved varieties, low fertilizer usage, no storage facilities, poor farm practices, high cost of farm inputs, inadequate market infrastructure, and poor access to water. These adversely affect the competitiveness and profitability of tomato production in Ghana (IFPRI, 2020, Robinson and Kalavalli, 2010).

According to AU (2020), the development of irrigation is an important catalyst for agricultural growth. Thus, the adoption of irrigation has significant positive impacts on households in terms of wealth creation and food security and a positive impact on the development of the economy in general. There are obvious and hidden benefits as well as private and public economic benefits derived from household investments in irrigation. Meanwhile, according to Abdoulkarimou and Mahamadou (2023), Agricultural production in the Sahel Environment fluctuates from one year to another, because of their strong dependence on rainfall. This emphasizes the importance of water technology in the productivity of crops and for that matter crop profitability and their competitiveness. The empirical evidence observed by Abdoulkarimou and Mahamadou (2023) showed that the yields of the wet season are significantly higher than those of the dry season.

The definition of the concept of competitiveness is varied in literature. It can be viewed from the microeconomic perspective as the comparison of the prices of the same commodity produced in two different places while the macroeconomic perspective is the capacity to augment the national share in world exports of goods and services. Porter and Sakakibara (2004) argued that Japan's development has benefitted from intense competition among firms' productivity. Amsden and Singh (1994), observed that competition policy in both Japan and Korea was oriented towards creating dynamic efficiency (the highest long-term productivity growth rate). Bouët et al., (2021) noted that competitiveness can be studied through its microeconomic drivers (labor costs, input costs, productivity, etc.) and macroeconomic drivers (trade costs, exchange rates, institutions, etc.). According to Daryanto (2009) and Latruffe (2010), the essence of an industry's competitiveness is efficiency and productivity. Therefore, one of the efforts that can be made to improve the competitiveness of a commodity from a micro perspective is to increase efficiency and productivity. Improving productivity will create comparative advantages for a commodity that can improve its competitiveness.

In the literature, several elements have been modeled as predictors of competitiveness. Hired labour costs, financing availability, land ownership, farmer organization, gender, off-farm income, and farm size are all factors to consider. According to Addai et al. (2014), access to productive inputs and extension education on input utilization, information, and training are management and technical services that, when facilitated by agricultural cooperatives, help boost productive performance. According to Abdul Fatah (2017), being a member of a farmer group improves rice producers' competitiveness in Malaysia.

Most empirical studies reveal that male farmers are more productive and competitive than female farmers. Female household heads were shown to be less productive than their male counterparts in mechanized fields in a study conducted in Sri Lanka by Siriwardana and Jayawardena (2014). Furthermore, a study in the Philippines and Malaysia indicated that women are less productive in rice production than men (Koirala et al., 2015, Abdul Fatah, 2017). Competitiveness can be affected by off-farm revenue. According to Goodwin and Mishra (2004), the decline in farm competitiveness may be due to less attention to on-farm productivity, such as using the best technologies and management practices. Also, the size of a farm has a favorable impact on its competitiveness. According to Abdul Fatah., (2017), other factors such as access to finance and land ownership, have no bearing on competitiveness.

Mohanty et al. (2002) analyzed data from five important agricultural production areas in India for efficiency using a modified policy analysis matrix (PAM) method and discovered inefficiency in the production of cotton in the country's second-largest producing state. According to the analysis, cotton is not the most efficient crop in the other four states; nevertheless, each state has at least one crop that is less efficient than cotton. According to these findings, Indian policies aimed at ensuring affordable cotton for the handloom and textile industries have resulted in significant inefficiencies in the cotton business.

Adegbite et al. (2014) assessed the competitiveness of pineapple production in Nigeria's Osun State. According to PAM results, the sucker production approach is more competitive. Using farm survey data from 165 farmers in two key maize-growing regions in northwestern Bangladesh, Rahman et al. (2016) assessed maize production's international competitiveness, profitability, output supply, and input demand. The data showed that maize production is competitive on a worldwide scale and, as a result, can effectively replace imports. Farm-level maize production is also profitable (Benefit-Cost Ratio = 1.21), and farm size has no effect on profitability.

Abdul Fatah (2017) investigated the relationship between rice production efficiency and competitiveness in Malaysia, using a stochastic frontier and policy analysis matrix and revealed that many farmers are competitive; over 60% of farms grow rice competitively, and these competitive farms account for a disproportionately large quantity of rice output when disaggregated data is used. The average figure was around 50-60%, indicating that many farms were located outside the boundary. However, rice yield per farm may be enhanced by making greater use of resources. The study identified the size of the farm; its organizational type; factor intensity; farm specialization; degree of commercialization; the farmer's age, education level/type, gender, and time spent on the farm as key determinants of competitiveness.

According to Lindawati et al., 2021, organic rice farming in the Beringin Subdistrict of Deli Serdang Regency had a Private Cost Ratio (PCR)<1 of 0.23, indicating that the farming business had a competitive advantage. Their results were also consistent with Widyatami et al., 2021, who showed that organic Rice farming had a comparative advantage in the Sumberjambe sub-district of Jember Regency with a Private Cost Ratio score of 0.537.

Competitiveness is the ability of organizations and farms to produce goods and services with a favourable quality-price ratio that guarantees profitability while achieving customer preference over competitors. Increasing tomato farm profitability and competitiveness requires the modernization of tomato farming techniques through structural reforms and policy implementation. An examination of the competitiveness of tomato production at the farm and aggregate levels can guide such policy formulations and their implementation.

The low-level competitiveness of smallholder tomato producers is driven mainly by low productivity and inefficiency (Mango et al., 2015). Thus, to increase competitiveness to incentivize tomato producers, policymakers need to understand the determinants of competitiveness. However, there is a lack of empirical evidence on rainfed and irrigated tomato production technologies in Ghana. In addition, recent empirical studies on competitiveness focused on Ghana's cashew sector, cocoa, and cassava value chain (Bannor et al., 2019).

The present study contributes to existing literature in two ways. First, unlike previous studies (Mohammed et al. (2016); Danso-Abeam et al. (2012) that focus on determinants of technical efficiency, the present study focuses exclusively on determinants of competitiveness of tomato farms in Ghana. Second, the study extends the discussion on competitiveness by estimating the distribution of competitiveness scores for each tomato farm under irrigation and rain-fed technologies using panel data.

Thus, arising from the foregoing, the study addresses the following research questions:

i. What is the level of competitiveness of tomato farms under irrigated and rainfed technologies?

ii. What are the determinants of competitiveness of Tomato production in Ghana?

The paper is structured as follows: section two presents the materials and method of the study, section three discusses the results, and section four presents conclusions and policy recommendations.

MATERIALS AND METHODS

Conceptual Framework

The agricultural production system involves the process by which managerial skills, technology, knowledge, and productive inputs are put together to produce a certain output. The output is obtained by the interactions of technical input factors, technical inefficiency factors, and stochastic factors (Aigner et al., 1977). Competitiveness is the ability of the farms to produce outputs with favourable quality-price ratio that guarantees profitability while achieving consumer preference over other competitors. In smallholder agricultural production, competitiveness is linked to factors such as household demographics, farm features, and the organization and management structure that farmers use (Battese and Coelli, 1995; Forsund et al., 1980). These factors, especially environmental factors are major determinants of the type of technology used in the production of tomatoes in Ghana. The type of production system depends on availability and accessibility to production inputs such as water, seed, fertilizers, mechanization, and access to the market for farm products, which impacts profitability and determines the level of competitiveness of the farm.

In Figure 1, the conceptual framework illustrates how the production levels, productivity levels, and competitiveness of the tomato farms cultivated under irrigated and rain-fed water technology systems are determined by the interaction of the demographic, socio-economic, environmental, and institutional factors as well as access to resources and services.

Measuring Competitiveness of Tomato Production

The competitiveness of tomato production in Ghana was estimated using the Policy Analysis Matrix (PAM) Model, developed by Monke and Pearson (1989) and recently used by Widyatami et al., 2021, Mohammed and Ibrahim (2023) to estimate the competitiveness of tomato farms under the irrigation and rainfed production technologies in Ghana. It is a matrix of two-way accounting identities made up of profit and loss identities (Nelson and Panggabean, 1991).

Following Abdul Fatah (2017), the Policy Analysis Matrix (PAM) Model was used to determine the price competitiveness of Ghanaian tomatoes as shown in Table 1. The Policy Analysis Matrix was used to calculate the Private Cost Ratio (PCB), Social Cost-Benefit Ratio (SCB).

In many developing countries where price distortions are common, analysts have used the PAM method and associated indicators such as the SCB and PCB (Reig-Martnez et al., 2008; Zheng et al., 2018, Abdul-Fatah, 2017). However, one of the primary flaws of PAM analysis to date is that it uses aggregate data. Because judgments based on average statistics can mask major variances in competitiveness among different firms, this information on sectoral competitiveness is insufficient (Nivievskyi et al., 2010; Von Cramon-Taubadel and Nivyevskyi 2009). According to Morrison and Balcombe (2002), this weakness can be improved by resampling the bootstrapping method's data.

Von Cramon-Taubadel and Nivyevskyi (2009) proposed the use of farm-level survey data to calculate the distributions of PAM indicators. This was accomplished by estimating SCB distributions for various agricultural items utilizing kernel approaches across a large sample of farms in Ukraine. They estimated the percentage of farms that produce competitively for each product, as well as the percentage of total production that is competitively produced for that product. To deal with this limitation, the study used the kernel method to estimate the competitiveness (Social Cost Benefit) using aggregate data from the respective production technologies, to eliminate any possible variations arising from the production technology-related heterogeneity among producers.

Where, the subscript *i* refer to outputs and the subscript *j*

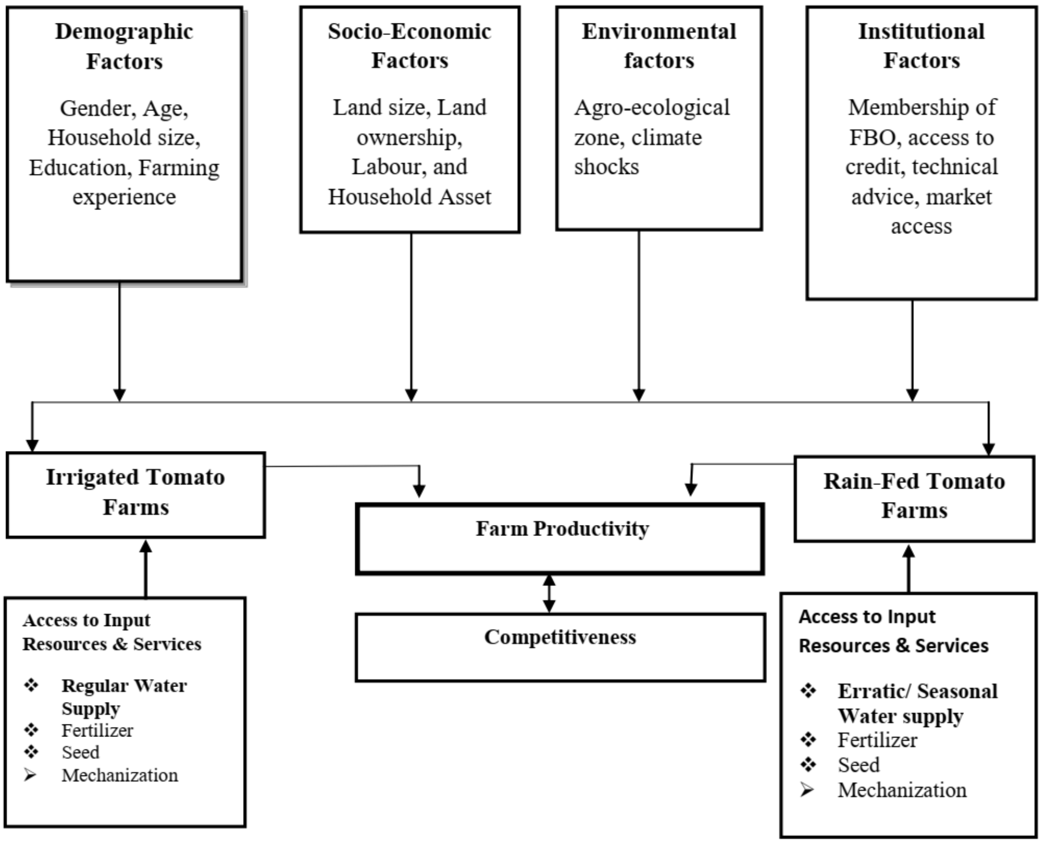

Figure 1: Diagrammatic Illustration of the Conceptual Framework

Source: Authors depiction, 2023

Table 1. Basic Elements of Policy Analysis Matrix

Items	Revenue	Cost		Profit
		Tradable Input	Non-Tradable Input	
Private Prices	$A = P_i^D$	$B = \sum_{j=1}^{k} a_{ij} P_j^D$	$C = \sum_{j=k+1}^{n} a_{ij} W_j^D$	D = A-(B+C)
Social Prices	E = P_i^S	$F = \sum_{j=1}^{k} a_{ij} P_j^S$	$G = \sum_{j=k+1}^{n} a_{ij} W_j^S$	H = E-(F+G)
Policy Transfer	I = A – E	J =B – F	K = C – G	L = D – H / L = I-(J+K)

Source: Adapted from *Abdul-Fatah,* 2017

refers to inputs; the superscript *D* refer to Domestic Prices and the superscript *S* refers to international prices; a_{ij} for (*j= 1 to k*) are technical coefficients in the manufacturing of *i* for exchanged inputs; a_{ij} for (*j=k+1 to n*) are technical coefficients for domestic inputs in the production of *i*; A (P_i^D) – Value of marketable output at market price for a tomato-growing operation; B (P_j^D)– Total cost of tradable inputs at market prices for a tomato-growing operation; C (W_j^D) - Total cost of non-tradable inputs at market prices for a tomato-growing activity; E (P_i^S) – Revenue calculated using production prices of output *i* at the border; F (P_j^S)– The price of a tradable input j calculated using international prices; G (W_j^S) – The price of a non-tradable input j was calculated using international prices; D: A–(B+C) – Private

Profitability; H: E–(F+G) – Social Profitability; I: A–E – Output Transfers; J: B–F– Input Transfers; K: C–G– Factor Transfers; and L:D–H– Net Policy Transfers.

Private Cost Ratio

The Domestic Non-Tradable Input to the difference between tradable output and tradable input at market price is known as the private cost ratio (PCR). The private value added is the difference between a marketable product and an input at market pricing. The following is the private cost ratio:

$$PCB = \frac{C}{A-B} \quad (1)$$

Where:
A= tradable output at market prices
B= tradable input at market prices
C = Domestic Non-Tradable Input at market prices

A PCB value of less than one shows that a portion of the private value-added compensates domestic variables and receives a share of the normal extra profit. When *PCB* = 1, it means that the domestic non-tradable is compensated by the value-added at market price. There is no regular additional profit. At market prices, it signifies the break-even point. The value-added does not compensate for the non-tradable domestic input if PCB is more than 1. The value-added activity results in losses at market prices. It is not profitable to perform an action that provides value.

Social Cost-Benefit (SCB)

The Social Cost-Benefit (SCB) ratio is one of the metrics that may be used to quantify competitiveness using Monke and Pearson's Policy Analysis Matrix (PAM) framework. It is defined as follows:

$$SCB = [\sum_{j=1}^{k} a_{ij}P_j^s + \sum_{j=k+1}^{n} a_{ij}W_j^s]/P_i^s \quad (2)$$

where P_i represents the price of the output i, P_j represents the prices of the k tradeable inputs, W_j represents the prices of the $n-k$ non-tradable inputs, and a_{ij} represents technical coefficients that represent the quantity of input j necessary to generate one unit of output i. The superscript indicates that social prices are used rather than private prices throughout. As a result, the ratio of the social cost to that of the social value involved in the production of a unit of output is the Social Cost-Benefit (SCB). To be competitive, the activity must have an SCB > 0. For the activity to be said to be non-competitive, its social cost must outweigh its social value indicated by an SCB > 1.

Modeling the Determinants of Competitiveness of Tomato Production

The following dynamic panel data model is used to explain differences in farm competitiveness:

$$Q_{it} = \beta_1 Q_{it-1} + \beta_2 Z_{it-1} + a_i + \varepsilon_{it} \quad (3)$$

Where Q_{it} is farm i's SCB score in period t, farm size, access to financing, off-farm income, landownership, hired cost of labour, farmers' organization, land holding, gender, and a temporal trend are all examples of explanatory variables in Z_{it-1}, and a_i an ε_{it} are error terms (unobserved and time constant farm-specific effects are captured by a_i and ε_{it} is an idiosyncratic error term). The explanatory variables used in this model were based on theoretical considerations and data availability. To find the optimum model specification, the researchers used the system generalized method of moments (SGMM).

The evaluation considered the economic and social opportunity costs of the resources used, which included capital, labour, and intermediate inputs. The cost of labour was used to value it. The economic cost of work is determined by whether it is skilled or unskilled labour, as well as the task that labour was hired to complete along the value chain. The opportunity cost of labour was used to estimate family labour. Physical inputs with a longer economic life than a single manufacturing phase are referred to as capital inputs. Machinery, construction, repair, and maintenance were among them. Land is not included in this analysis, but building and machinery are. The study's economic cost of capital inputs was calculated using the straight-line method.

The Study Areas and Sampling Strategy

Study Area

The study was conducted in four agroecological zones predominantly recognized for commercial tomato farming namely, Guinea Savanna, Forest Zone, Forest-Savanna Transition, and Coastal Savanna Zones (Figure 2). Ghana is separated into six distinct agroecological zones based on climate and soil types. The Guinea savannah zone (GS), Forest-savannah transition zone (FST), Deciduous Forest zone (SDF), Sudan savannah zone (SS), Coastal savannah zone (CS), and Rain-forest zone (FZ) (moist and wet evergreen) are the several types of ecological zones (FAO, 2005). The forest, transitional, and coastal zones have two rainfall regimes, ensuring agricultural output across two seasons, but the savannah zones only have one rainfall regime, allowing crop production in a single season (MOFA, 2015).

As displayed in Table 2, crop yields in these zones vary based on the weather conditions, soil types, and natural vegetation cover of the different zones. The FST zone is 8400 km^2 in size and receives an average rainfall of 1300 mm per year. The main rainy season is from March to July, while the secondary rainy season is from September to October (FAO, 2005). The Guinea Savannah has a short

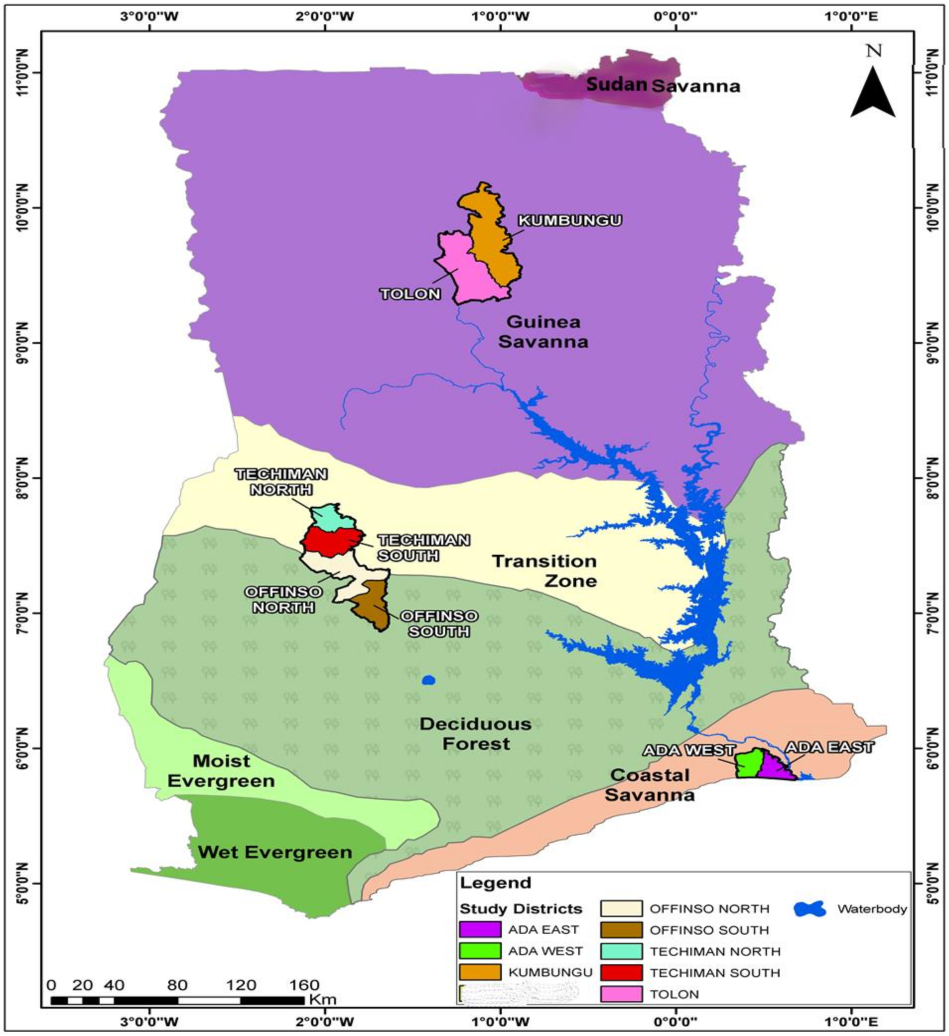

Figure 2: The Map of Ghana Showing the Agro-ecological Zones

Source: Authors' Depiction, 2020

Table 2. Characteristics of agro-ecological zones in Ghana

Zone	Rainfall (mm/yr)	Portion of Total Area (%)	Cultivation Period (days)		Dominant Land Use
			Major Season	Minor Season	
Rain Forest	2200	3	150 - 160	100	Forest, plantations
Deciduous Forest	1500	3	150 - 160	90	Forest, plantations
Forest Savanna Transition	1300	28			Annual food and cash crops
Guinea Savanna	1100	63	180 - 200		Annual food, cash crops and livestock
Sudan Savanna	1000	1	150 - 160		Annual food crops and livestock
Coastal Savanna	800	2	100 - 110	50	Annual food crops

Source: MOFA, 2018

unimodal tropical monsoon with an average annual rainfall of 1,100 mm and a wet season of 180–200 days. (GSS, 2012). The Sudan Savannah receives less rain, with an average annual rainfall of 1,000 mm and 150–160 rainy days. There are 180 to 210 dry days (November to mid-April) with dusty harmattan breezes and a high temperature of 35 degrees Celsius during the day between November and February (GSS, 2012).

Table 3. Sample Size by Ecological Zones

Zones	Districts	Irrigated	Rainfed	Total
Costal Savanna	Ada West, Ada East	59	140	199
Forest Zone	Offinso North, Offinso South	44	103	147
Forest Savanna	Techiman North, Techiman South	54	97	151
Guinea Savanna	Tolon, Kumbungu	49	152	201
Total		206	492	698

Source: Authors, 2020

Sampling Strategy

A multi-stage sampling technique was used in the investigation. In the first stage, purposive sampling was used to select the four primary ecological zones: Guinea Savanna, Forest Zone, Forest-Savanna Transition, and Coastal Savanna Zone based on the history of tomato production and the predominance of production of same according to the Ministry of Food and Agriculture Progress Report 2017. Again, a purposive sampling technique was used to select two districts from each of the four ecological zones. At the end of data collection process, 206 farms were randomly selected among 4000 irrigated farm households, based on information provided by the Ghana Irrigation Development Authority (GIDA). Additionally, 492 rainfed tomato farmers were interviewed. In total, 698 tomato farmers were interviewed, comprising 206 irrigated farmers and 492 rainfed farmers from four ecological zones in Ghana, making it a total of 2094 observations as displayed in Table 3. The sample size in each ecological zone was selected based on proportional sampling to ensure the representativeness of the sample. Based on the number of farming households in each community in the sampled districts in the specified ecological zones, the number of households again was proportionally allocated as shown in Table 3.

Data Collection

The data collection began on October 5th, 2019, and finished on January 8th, 2020. Both secondary and primary data sources were used in the study. The secondary data was primarily gathered through a review of published and unpublished literature. The study also used a three-year (2017-2019) farm-level recall panel dataset (Collected on spot through a process of recall by the farmers) with sets of primary data encompassing information on tomato production as well as other demography, institutional, and socioeconomic characteristics. To improve the recall data, the questionnaire was administered in local languages with the assistance of local enumerators recruited and trained on how to ask off script questions in order confirm information given by the farmers to eliminate the tendency of socially desirable responses from the farmers. The enumerators were also trained on how to elucidate answers that will allow for easy standardization of metric responses. The enumerators were selected from a pool of qualified field enumerators used for data collection by the Department of Agricultural Economics and Agribusiness.

The information collected included farm and farmer-specific information such as age, gender, experience, and education. Secondary data was obtained from the Ministry of Food and Agriculture, the Ghana Statistical Service, the Food and Agriculture Organization, the Ghana Meteorological Service, the Ministry of Finance, and the Bank of Ghana, among others. Import parity or export parity prices are used to calculate social prices for traded commodities. Because Ghana imports tomatoes often, the social price of tomatoes was calculated using an import parity price. The World Bank and the FAO database were used to gather fertilizer (NPK) cost, insurance, and freight (CIF) pricing. Fuel prices and pesticides were provided by the Ministry of Trade and Industry, the Ghana Statistical Service, and FAOSTAT, while salaries were provided by the Ministry of Trade and Industry, the Ghana Statistical Service, and FAOSTAT.

RESULTS AND DISCUSSIONS

Competitiveness of Tomato Production under different technologies

The policy analysis matrix was used to estimate the competitiveness of tomato farms by calculating the Social Cost-Benefit (SCB), and Private Cost Benefit (PCB) to determine the level of competitiveness of Ghana's tomato sub-sector.

The SCB or PCB ratios, which are smaller than 1, imply that tomato farming under the mentioned technologies is profitable and for that matter competitive. According to Table 4, the two systems barely show a comparative advantage in tomato production, with an estimated SCB ratio surpassing unity.

The empirical results showed that producing tomatoes under the two technologies was competitive with a comparative advantage score of less than one (PCR < 1). Tomato production is lucrative based on net return and undiscounted PCR in the studied areas.

From Tables 4 and 5, the results from the Social Cost-Benefit (SCB) ratio revealed that in all the years, the estimated SCB was greater than 1, ranging from 1.311 to

Table 4. Estimates of Indicators of Tomato Competitiveness

Indicator	Irrigated	Rain-fed	Pooled	t-test	p-values
Private Cost Ratio					
PC	1927.070	1925.990	1926.340	-0.154	0.877
PCR	0.014	0.010	0.012	-0.070	0.944
Social Cost Benefit Ratio					
SC	2302.280	2300.790	2301.270	-0.128	0.898
SCB	3.215	2.026	2.413	-0.713	0.476

Source: Authors Computation from Field Data, 2023

Table 5. Yearly Breakdown of Estimates for the Indicators of Competitiveness

Indicator	2017		2018		2019	
	SCB	PCR	SCB	PCR	SCB	PCR
Irrigated	1.311	0.034	1.623	-0.021	4.315	0.022
Rain-fed	1.857	0.038	1.454	-0.031	2.771	0.024
Pooled	1.311	0.035	1.623	-0.022	3.315	0.322

Source: Authors Computation, 2023

Table 6. Disaggregated Farm-Level Competitiveness and its Production (2017- 2019)

Year	Distribution of Tomato Farms	Competitive (SCB<1)	Uncompetitive (SCB>1)
2017	Average SCB score among sampled farms	0.65	2.5
	Farm Level Competitiveness (%)	69.19	30.81
	Production level per group (%)	86.14	13.86
2018	Average SCB score among sampled farms	0.61	2.66
	Farm Level Competitiveness (%)	73.04	26.96
	Production level per group (%)	89.89	10.11
2019	Average SCB score among sampled farms	0.66	2.66
	Farm Level Competitiveness (%)	60.74	39.26
	Production level per group (%)	81.83	18.17

Source: Authors Computation, 2023

4.315. This implies that the tomato farms at the aggregate levels are not competitive. Also, the estimated Private Cost Ratio is less than 1. This shows that under the different production technologies, the tomato farms were competitive.

Table 6 summarizes the disaggregated farm-level results of the SCB analysis of tomato production from 2017 to 2019. The results showed that decomposing the Social Cost-Benefit (SCB) at the individual farm level revealed that a significantly large proportion of the tomato farms were competitive with SCB scores less than one. According to the findings, in 2017, more than 69.19 percent of farms produced tomatoes competitively, accounting for 86.14 percent of total tomato output in the given year. Similarly, about 73.04% of the farms were competitive in 2018 and produced 89.89% of the total tomato output in that year.

About 60.74% of the tomato farms under study were also competitive and produced nearly 81.83% of the farm output in 2019. There is no significant difference in competitiveness among tomato-growing farms utilizing the two technologies. This indicates that many small farms can produce tomatoes profitably by utilizing both approaches.

Determinants of Tomato Farming Competitiveness

The findings from the System Generalized Method of Moments (SGMM) are shown in Table 7. The null hypothesis of no serial correlation between instruments and error terms cannot be rejected based on the findings of the difference-in-Hansen test, showing that the over-identifying limitations are valid. The Arellano-Bond test for AR (1) reveals that the residuals are negatively correlated, which is consistent with the first-difference process in SGMM method. Furthermore, the null hypothesis of zero autocorrelation is not rejected, in the first difference at order 2 (AR2). Because higher SCB scores (SCB > 1) indicate lower competitiveness, a positive calculated coefficient means the explanatory variable raises the SCB and thus lowers competitiveness.

Table 7 illustrates that access to credit, yield, access to extension services, fertilizer price, FBO, and farm location all have a major impact on producers' competitiveness.

Table 7. Estimates of Factors Influencing Tomato Producers' Competitiveness

	Dependent Variable: SCB score					
Explanatory variables	**Pooled**		**Irrigated Farmers**		**Rain-Fed Farmers**	
	Coeff.	**Stand.**	**Coeff.**	**Stand.**	**Coeff.**	**Stand.**
Year of Education	0.145	0.350	0.089	0.662	-0.002	0.135
Household size	0.582	0.458	0.248	0.779	0.064	0.158
Farm size	0.864	1.130	-0.437	1.078	-0.003	0.021
Experience	0.134	0.127	0.250	0.180	-0.092	0.079
Age	0.294**	0.118	-0.057	0.153	0.050	0.052
Sex	11.503***	4.139	6.349	3.951	2.002	1.316
FBO	-3.549**	1.601	-1.060	1.647	-1.148**	0.574
Extension Services	-6.173***	2.335	-1.421	3.482	0.221	0.774
Access to credit	-5.257**	2.357	-5.615	3.589	-2.429*	1.472
Land tenure	-0.878	2.216	-0.377	3.112	0.419	1.408
Yield(log)	-0.150***	0.028	-0.012***	0.003	-0.127*	0.069
Fertilizer Price (log)	0.200***	0.068	0.157**	0.080	0.302**	0.157
Time	-0.0052	0.0031	-0.025***	0.008	-0.040	0.136
Forest zone	2.748	3.735	-1.815	6.492	-2.472	1.669
Transitional zone	6.585*	3.771	-9.286	5.894	0.653	2.905
Guinea Savannah zone	-0.732	1.768	-10.32*	6.255	-3.242*	1.779
Cont.	5.360	2.340	9.165	3.151	1.474	2.283
Number of Observ.	1820		594		1226	
Number of groups	697		448		649	
Arellano-Bond test AR (1)	-1.94		[0.065]			
Arellano-Bond test AR (2)	-0.74		[0.459]			
Difference-In-Hansen Tests of Exogeneity of Instrument Subsets	2.61		[0.855]			

*, **, ***= 10%, 5% and 1%

Source: Authors Computation, 2023

Growers who join a farmer's association collectively appear to profit more socially and economically than those who do not. The findings support farmer groups' statements that facilitating access to productive inputs and technical, and management services such as training, information, and input application extension can assist their members in enhancing their market performance (Addai et al., 2014). Several empirical findings in the literature show that farmer groups play an important influence in the adoption of productivity-enhancing technologies (Spielman et al., 2011; Abebaw and Haile, 2013; Ainembabazi et al*.,* 2017), whiles other research has shown the importance of farmer groups in increasing output and technical efficiency (e.g. Abate et al., 2014; Ainembabazi et al., 2017). To improve rural service delivery and market access, as well as lower transaction costs and promote competitiveness, many governments must use technology and improve efficiency to develop farmer-based organizations.

Farmers who are male are thought to be more competitive than those who are females. Male tomato producers made higher social profits and were more competitive than female tomato farmers. This could be a result of the fact that female farmers' have limited access to production resources compared to their male colleagues. Several prior research on the impact of gender on agricultural production have yielded similar results. In mechanized fields, men family heads were shown to be more productive than female household heads in a study conducted in Sri Lanka by Siriwardana and Jayawardena (2014).

In a study conducted in the Philippines, Koirala et al. (2015) revealed that female heads of households were less productive in rice production than male heads of households, a conclusion the authors attributed to culture, land access, and economic factors. Furthermore, according to Codjo et al. (2019), male rice producers in Benin are more competitive than females. This could be because women and men face different obstacles, like inequality in land access, labour, and market expertise. Female farmers in Ghana, particularly in the Northern Region, are less likely to cultivate vast plots of land or embrace upgraded technology. They face challenges like inequality when accessing property, financing, and credit, which limit their ability to compete with their male counterparts.

The SCB of producers has a yield elasticity of 0.150. As a result, a 1 percent increase in tomato yield would result in a 0.150 percent drop in SCB *ceteris paribus* and, for that matter a 0.150 percent increase in competitiveness. In irrigated and rainfed technologies, however, a 1 percent increase in yield reduces SCB score by 0.012 and 0.127 percent, respectively leading to a respective rise in producers' competitiveness. The current outcome is consistent with Adégbola and Sodjinou (2003) and Codjo et al. (2016) findings, where a producer's competitiveness in all production systems depends on how high the yield is.

Fertilizer price has a positive and significant effect on competitiveness at 1 percent. Producers' SCB has an elasticity of 0.20 in relation to fertilizer prices. This means a 1 percent rise in fertilizer price increases the overall SCB by 0.20 percent *ceteris paribus*, while under the irrigated and rainfed technologies, a 1 percent rise in fertilizer price will increase the SCB score by 0.157 and 0.30 percent respectively. The findings demonstrate that a rise in fertilizer prices has a negative effect on the competitiveness of Ghanaian tomato growers. As a result, a policy such as a fertilizer subsidy programme that would allow producers to acquire fertilizer at a low price would enhance their level of competitiveness. The outcome of this study implies that the competitiveness of tomato production in Ghana can be increased by focusing on the identified drivers and putting policies and programmes that will help reduce the SCB of tomato farmers. Furthermore, because high labour costs hurt farmers' competitiveness, the government must put mechanisms to improve access to mechanization and improved seed varieties. Overall, policy initiatives should favor access to a variety of inputs at the lowest possible cost to promote competitiveness.

CONCLUSION

This paper employed the Policy Analysis Matrix (PAM) Model to estimate the competitiveness of tomato production in Ghana. A multi-stage sampling technique was employed to sample about 698 tomato farmers comprising 206 irrigated farmers and 492 rainfed farmers over a period of three years between 2017 and 2019 from four selected ecological zones including Guinea Savanna, Forest Zone, Forest-Savanna Transition, and Coastal Savanna Zone.

We found that many farmers are competitive at the farm level and these competitive farms produce a disproportionately large volume of tomatoes. According to the disaggregated statistics, about 60.74% of tomato farms are competitive and produced nearly 81.83 of farm output in 2019.

The study also shows that farmer engagement, farm size, access to credit, and extension service are the most important factors in explaining the competitiveness of tomato production, while gender and farming in the Forest-Savanna Transitional agroecological zone may diminish the level of farmers' competitiveness.

The study revealed that at the aggregate level tomato farmers under both irrigated and rainfed tomato production technologies were uncompetitive. However, disaggregated data at the farm level shows that many tomato farmers were competitive, and these competitive farms produced a disproportionately large amount of tomatoes during the period of study.

Finally, the size of tomato farms, availability of credit, and access to extension services are the most important factors influencing tomato farmers' competitiveness in Ghana.

Policy Recommendations

Based on these conclusions, the paper recommends that policymakers pay attention to improvement in the productivity of tomato farms as a major driver for accelerating the nation's competitiveness in tomato production. Thus, policy efforts aimed at increasing competitiveness must be targeted at developing efficient irrigation technology in the tomato sub-sector, especially as it holds greater potential for an exponential increase in productivity. Agricultural finance, its availability, and access should be a priority on the agenda of policymakers to improve tomato competitiveness. The government's agricultural policy for the tomato subsector must also focus on improving farmer engagement, enhancing access to technical support and extension services, and promoting a shift from smallholder production to the commercial cultivation of tomatoes.

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Conflict of interests

The authors declare that they have no conflicting interests

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