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Estimating Technical Efficiency of Tomato Production in Northern Ghana

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Authors' contributions

This work was carried out with the involvement of all authors. Authors MT and NA were involved in the questionnaire design as well as the data collection and entry, while SAD did the analyses and final write-up. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Aim: To investigate the factors influencing technical efficiency of tomato farmers at the Irrigation Company of Upper Region (ICOUR).
Study Design: Cross sectional.
Place and Duration: Kasena-Nankana District of the Upper East Region of Ghana in the 2007/2008 cropping season.
Methodology: One-step estimation of the Cobb-Douglas Stochastic Frontier Model.
Results: Mean technical efficiency was found to be 0.71, ranging from 0.36 and 0.99. The relatively high efficiency levels were as a result of agricultural intensification measures (such as the adoption of modern inputs) that the farmers followed as well as high levels of education and long years of experience in cultivating tomatoes. The most indentified effect of tomato influx into the country was that it drives farmers out of production. As a way out the farmers suggested that there should be a review of the country's cross border relations with its neighbors.
Conclusion: The farmers at ICOUR are technically efficient. Their main problem however borders on the fierce competition they face from their foreign counterparts.

Keywords: Cobb-Douglas stochastic frontier model; ICOUR; technical efficiency; tomatoes.

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ABBREVIATIONS

AE : Allocative Efficiency.
ECOWAS : Economic Community of West African States.
EE : Economic Efficiency.
ERP/SAP : Economic Recovery Programme/Structural Adjustment Programme.
EU : European Union.
FAO : Food and Agriculture Organization.
FASDEP : Food and Agriculture Sector Development Policy.
GDP : Gross Domestic Product.
GPRS : Growth and Poverty Reduction Strategy.
HYV : High Yielding Varieties.
ICOUR : Irrigation Company of Upper Region.
IFAD : International Fund for Agricultural Development.
MoFA : Ministry of Food and Agriculture.
MDAs : Ministries, Departments and Agencies.
SSA : Sub-Saharan Africa (SSA).
SADA : Savanna Accelerated Development Authority.
TE : Technical Efficiency.

1. INTRODUCTION

While hunger and poverty are found in all the regions of the world, sub Sahara Africa (SSA) is the only region where per capita food production has failed to increase since 1980 [1]. Agriculture in SSA is faced with a number of problems, including land degradation and declining soil fertility. The declining fertility of soils is due to increasing land pressures resulting from rapid population growth. In addition, most soils of humid tropical Africa are sandy, highly weathered, low in organic matter content and susceptible to soil erosion and compaction. The effect is that yields, and for that matter, farm incomes, is low, worsening the poor living standards of farmers. [1] intimates that intensive use of land will require improved technologies generated through research as well as improved irrigation systems. Other measures include education and incentives created through changes in institutions such as land tenure systems, input, credit and pricing policies.

Tomato production is one of the most important farming activities in the world, believed to reduce food and cash insecurity. In 2008, China, the world's leading producer recorded the highest production level of over 33. 9 million tones followed by the United States, also recording about 13.7 million tones. In SSA, Nigeria recorded the highest production level of 1.7 million. In Ghana, tomato is one of the most important income-generating vegetables cultivated in Ghana. The crop is cultivated continuously throughout the year because apart from the rain-fed system that normally spans between June and November in the southern part of the country, there is the dry-season system between October and April mainly in the north (especially in the upper east). In 2008, the total tomato cropped area was 16,130 hectares, and the estimated production was 284, 000 metric tons. Thus, the crop yield was 17.6 metric tons. In 2010 however, production level rose to 35,000 metric tons, valuing $129,347,000 [2].

In 2007, a Ghanaian newspaper ran a headline, following the disclosure by parliamentarians from northern Ghana, to the effect that suicide attempts through self poisoning were on the

increase in the three northern regions, especially the UER [3]. The reason for the suicide attempts was that some farmers were frustrated because they incurred huge debts as a result of poor marketing of their produce during the season in question. The news item did not come as a surprise to many, because a casual observation along the Tamale-Bolgatanga road during the tomato season reveals dozens of crates of tomatoes along the road with their owners literally begging the market women from the south of the country to buy them. This was the initial motivation for the study; to find out the extent to which the farmers were efficient in their farming business, and the possible determinants of such efficiency, as well as the marketing challenges facing them.

1.1 Background to the Economy of Ghana

Ghana is located on the West African Gulf of Guinea, 5°36´N of the equator and 0°10´E. Half of the country lies less than 152 meters (500ft) above sea level, and the highest point is 883 meters (2,900ft). The country is bounded in the east by Togo, the west by Cote d'Ivoire and in the north by Burkina Faso. It covers a total area of 238,540 km^2. Formed from the merger of the British colony of the Gold Coast and the Togolese trust territory, Ghana in 1957 became the first SSA country in colonial Africa to gain independence. At the early stages of independence, Ghana's economy was among the strongest in the then middle income countries. However, Ghana had been a less developed country until 2010, when a rebasing of the economy (at constant 2006 prices) put the country at a lower middle income level. The population of Ghana as at 2010 stood at 24.4 million with an annual growth rate of 2.4%. Gross Domestic Product (GDP) as at 2010 was 32.3 billion US dollars with a growth rate of 7.7%. The per capita income was 1,325 US dollars. In 2008, GDP grew by 7.3% and 7.7% in 2010. Until 2010, the agricultural sector remained the highest contribution to GDP and employment. However, with the rebasing of the economy, the services sector contributed 51.4%, followed by agriculture 29.9% and the industry sector 18.6% [4].

It is estimated that on average 90% of the farm holders in Ghana are small scale, 9% are medium scale and 1% large scale with average holdings of 4.2, 21.7 and 57 acres respectively. For the entire country the average land holding is about 6.4 acres (2.56 hectares) [5]. There are two main types of farming in Ghana, namely, the traditional and the modern. The former is more common than the latter. The traditional type of farming is practised mostly by the small scale farmers. While in the past this used to be on purely subsistence level, in recent times it could be partly for cash. The traditional type of farming involves the use of simple tools like cutlasses and hoes for weeding, digging and harvesting, among others. There is little or no use of chemical fertilizers, instead bush fallowing and shifting cultivation are relied upon for the soil fertility maintenance. The use of mechanization is limited, and except in the north, there is no use of animal traction. Household labour is the main source of labour and in some instances group labour is used. The crops grown are mainly tubers, cereals, legumes and vegetables. The modern type of farming system employs modern methods of farming. It is mostly associated with plantation crops. There is use of farm machinery like tractors for clearing the lands in addition to human labour. The use of farm animals is also common especially in the north. There is also the use of irrigation facilities, high yielding varieties (HYV) seeds, pesticides and also inorganic fertilizers.

Ghana is divided into ten (10) administrative regions, namely: Greater Accra (the national capital), Central (the former national capital), Eastern, Western, Volta, Ashanti, Brong Ahafo, Northern, Upper East and Upper West regions. The southern part of Ghana is generally more developed than the north [6]. For instance, all the headquarters of government ministries as well as the two main international ports are located in the national capital. The

further one travels from the Greater Accra region, the less the level of development and economic resources.

1.2 Northern Ghana and the Upper East Region

Northern Ghana comprises three regions: the Upper East region (UER); the Upper West region (UWR) and the Northern region (NR). These regions cover an area extending approximately between latitudes 80N and 110N. They constitute over 40% of the entire land area of Ghana, but contain about 20% of the national population. The three northern regions are among the poorest in the country. The Ghana Living Standards Survey [7] reveals that the NR, UER, UWR, CR and WR have the highest incidence of poverty, where more than 50% of the people live below the poverty line (i.e. Live on less than US$1 a day) and 30% live below the extreme poverty line (i.e. People living on less than ¼ of a dollar per day).

The UER is located in the north-eastern corner of the It is bordered to the north by Burkina Faso, the east by the Republic of Togo, the west by Sissala in Upper West, and the south by West Mamprusi in Northern Region. The land is relatively flat with a few hills to the east and southeast. The total land area is about 8,842 sq km, which constitutes about 2.7 per cent of the total land area of the country. The region's soil is "upland soil" mainly developed from granite rocks. It is not only shallow and low in soil fertility, but it is weak with low organic matter content and basically coarse textured. In the valleys, the soils range from sandy loams to salty clays. They have higher natural fertility but are more difficult to till and are prone to seasonal water logging and floods. Like northern Ghana in general the UER experiences one rainy season from May/June to September/October with mean annual rainfall within this period ranging between 800mm and 1100mm. There is however, a long spell of dry season from November to mid February which is characterized by cold, dry and dusty harmattan winds. Humidity is, however, very low, making the daytime temperature comfortable. The natural vegetation of the region is the savannah woodland, characterized by short scattered drought-resistant trees and grasses. Agriculture is one of the main economic activities in the region. About eighty percent of the economically active population engages in agriculture. The main produce are millet, guinea-corn, maize, groundnut, beans, sorghum and dry season tomatoes and onions. Livestock and poultry production are also important. Like northern Ghana in general the harsh climatic conditions of the UER are a limiting factor for the region to attract both material resources and human capital. As a consequence industrial activity in the region is relatively low.

1.3 National Agricultural Policy

In Ghana the Ministry of Food and Agriculture (MoFA) is the main ministry responsible for policy and planning for the agriculture sector. In recent years two of the policy documents that MoFA has designed in collaboration with other stakeholders, is the Food and Agriculture Sector Development Policy (FASDEP I & II). FASDEP I was designed in 2002 and was "meant to provide a framework for modernising the agricultural sector and making it a catalyst for rural transformation, in line with the goal set for the sector in the Ghana poverty reduction strategy (GPRS I)" [8]. However, a poverty and social impact analysis (PSIA) of FASDEP I, revealed that the policies would not be able to achieve the desired impact on poverty. It was against this backdrop that FASDEP II was designed to provide the conducive atmosphere for all categories of farmers, especially the small scale farmers. Another important document that is of particular relevance to northern Ghana is the savannah accelerated development authority (SADA). It is a government policy initiative aimed at

addressing the development gap that exists between northern and southern Ghana. The mandate of SADA is to accelerate the socio-economic development of the savannah belt through strategic investment in resource development. It envisions a "forested north" by 2030 where agricultural production is modernised and oriented towards a larger market. This vision is built on the food and agriculture sector development programme (FASDEP) II document.

1.4 History of Tomato Production in Ghana

As observed by the Third World Network (TWN) in [3] tomato production has been an important economic activity in Ghana, especially the UER, which is the poorest region in Ghana. Tomato production has been undertaken since 1960 on a commercial basis, benefiting from government's support. The support includes the establishment of dams and irrigation projects that provide water to the farms. One of such projects is the Tono Irrigation Projects built between 1975 and 1985 and covers a catchments area of 3,600 hectares. There are nine villages living and farming within the project area. About 90% of the people living here are engaged in the production and sale of tomatoes. The establishment of the dam allows for an all-year cultivation of tomatoes and other crops such as rice, onions and pepper. Another important support from government for the tomato industry was the establishment of three tomato canneries in the country producing tomato paste and puree. These were situated in Pwalugu, in the UER, Wenchi, in the Brong Ahafo (BA) and Nsawam in the ER, but near Accra. These canaries gave a further boost of the tomato industry as they entered into contract farming with most of the farmers, supplying them with inputs and giving them ready markets for their produce. In this way, exploitation by market women from Accra and Kumasi was reduced, if not eliminated. However, the tomato industry received a major blow with the introduction of Economic Recovery and Structural Adjustment Programmes (ERP/SAP) in the early 1980s when government was forced to privatize state-owned enterprises, including the three canneries. In addition, the deregulation and liberalization programmes meant that trade restrictions were relaxed, resulting in the importation of canned tomatoes, especially from the European Union (EU) where production is heavily subsidized. For instance, Ghana's imports of processed tomato preserves from the EU increased by 628% from 3,713 tons to 27,015 tonnes between 1993 and 2003. The EU market is not the only source of imported tomatoes in Ghana; in recent times local producers have faced fierce competition also from nearby Burkina Faso.

1.5 Objectives and Justification of the Study

The specific objectives of the study are to: (1) estimate the technical efficiency levels of the tomato farmers of the Tono Irrigation Project; (2) find out the determinants of the technical efficiency and (3) investigate the farmers' perceptions on the effects of tomato importation into the country and how such problems may be resolved. An investigation into technical efficiency, because as outlined in the subsequent sections, agriculture in Ghana, and for that matter, northern Ghana, is faced with numerous challenges, and so for farmers to produce so much that they cannot dispose them off suggests some efficiency that must be unearthed. Similarly, soliciting the farmers own opinions about the nature of the farming problems they face and how such problems may be overcome was not only a bottom-up approach to policy formulation, but it served as source of psychological relief, knowing that at least some people had come to listen to them.

1.6 Literature Review

1.6.1 Technical, allocative and economic efficiencies

Kumbhakar and Lovell and Coelli et al. [9,10] note that even though theoretical literature on productive efficiency started in the 1950s with the work of [11, 12,13,14] was the first to have carried out an empirical study on efficiency. He provided an empirical application to US agriculture using linear programming.

Farell [14] distinguished between two efficiencies, namely, technical and allocative efficiencies. While technical efficiency reflects the ability of a firm to obtain maximal output from a given set of inputs, allocative efficiency is the ability of a firm to use the inputs to optimal proportions, given their respective prices and the production technology. These two measures are then combined to produce a measure of economic efficiency. Fig. 1 below illustrates the types of efficiency as explained by [14]. A firm operating at M is technically efficient because it is operating on the isoquant $IS - IS^{'}$. However if a firm is operating at N it is not efficient because it is far away from M and indeed the origin 0. In this case the technical inefficiency of the latter may be measured by the distance MN, which is the amount by which the firm's inputs can be proportionally reduced without reducing output. Thus, in a ratio form the technical efficiency (TE) of this firm is measured by $TE_i = 0M / 0N$ which is equal to $1 - MN / 0N$. This implies that technical efficiency will take the value between zero and one. Thus a technical efficiency of one implies the firm is fully efficient (while zero efficiency implies the firm has no technical efficiency). From the diagram the input price ratio may be represented by the slope of the straight line $AS - AS'$. With this, the allocative efficiency (AE) of the firm can also be calculated. At point N the allocative efficiency is defined as the ratio $AE_i = 0P / 0M$ since the distance PM represents the reduction in (production) costs if production were to occur at the allocatively (and technically) efficient point instead of the technically efficient, but allocatively inefficient point M. The product of technical efficiency (AE) and allocative efficiency (AE) is economic efficiency (EE) given as:

$$EE = TE_i \times AE_i = (0M / 0N) \times (0P / 0M = (0P / 0N) \quad (1)$$

Like technical efficiency, allocative and economic efficiency are bounded by zero and one.

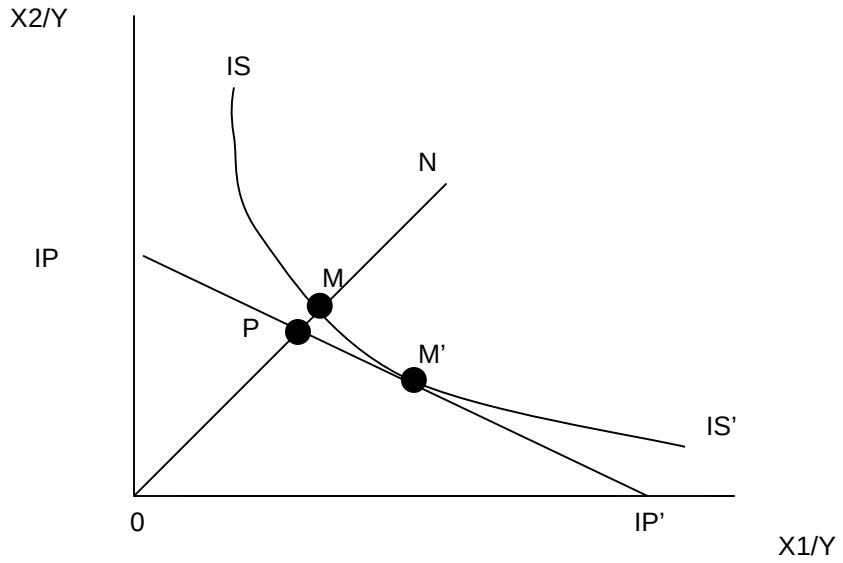

Fig. 1. Technical, allocative and economic efficiency

Farell [14] argues that in practice it is difficult to estimate a production function because it is not known. However, it can be estimated from a sample data using either a non-parametric piece-wise-linear technology or a parametric function such as the Cobb-Douglas functional form. [15] took up the former suggestion resulting in what has now come to be known as the data envelopment analysis (DEA) approach. The latter was taken up by researchers [16,17,18,19 20] subsequently resulting in the development of the stochastic frontier analysis (SFA). The evolution of efficiency studies and the stochastic frontier model is discussed in detail in [9, 21].

Battese and Coelli [20] stochastic frontier model (for cross sectional data) is specified as

$$\ln(y_i) = f(x_i; \quad) + v_i - u_i \tag{2}$$

$$\text{«}_i = z_i^{'}\text{¢} + e_i \tag{3}$$

Where:

y_i is output of the farm-firm “in natural logarithm”;

x_i is a $(1 \times k)$ vector of farm inputs “in natural logarithm”;

is a $(k \times 1)$ vector of parameters to be estimated; and

ln is natural logarithm.

Also, while v_i measures the random variation in output (Y_i) due to factors outside the control of the farm-firm such as weather and natural disasters, u_i on the other hand measures the factors (within the control of the firm) responsible for that firm’s inefficiency such as mismanagement, education and experience. v_i is assumed to be identically and

independently distributed as $N\left(0,\pm_{v}^{2}\right)$ random variables, independent of which is distributed as a truncated normal (at zero) of the $N\left(«_{i},\pm^{2}\right)$ distributions. Note that u_i is independently, but not identically distributed; In general, $£_{i}=v_{i}-u_{i}$ is the composed error term.

Furthermore, $\mathbf{z_i}$ is a $(k\times1)$ vector of socioeconomic factors affecting efficiency; $\boldsymbol{\delta}$ is a $(1\times k)$scalar parameters to be estimated and e_i is a two sided error term with $N\left(0,\pm_{e_2}^{2}\right)$. The other variables are as defined above.

From equation 2, TE can be estimated as:

$$\boldsymbol{TE}=\frac{\boldsymbol{y_i}}{\boldsymbol{y_i^*}}=\frac{\boldsymbol{f(x_i,\beta)e^{(v_i-u_i)}}}{\boldsymbol{f(x_i,\beta)e^{v_i}}}=\boldsymbol{e^{-u_i}}\ (\text{So that}\leq \boldsymbol{TE}\leq \mathbf{1}) \quad (4)$$

Thus as implied from Fig. 1, TE is defined as the ratio of the observed output for the i-th farm-firm, relative to the potential output, defined by the frontier function, given the input vector, xi. The log-likelihood function for the stochastic frontier and inefficiency model in addition to the first partial derivatives of the lcg-likelihood function with respect to the different parameters of the model is presented in the appendix in [19]. The variance parameters are given as $\boldsymbol{\sigma_s^2=\sigma_v^2+\sigma^2}$, where $\boldsymbol{\gamma=\sigma^2/\sigma_s^2}$. Note also that $\mathbf{0}\leq\boldsymbol{\gamma}\leq\mathbf{1}$

2. METHODOLOGY

Following from equations 6 and 7 the empirical model that specifies the technical efficiency of tomato farmers at ICOUR is:

$$In(Y_i)=\beta_0+\beta_1 In(land)+\beta_2\, In(Family\ labour)+\beta_3 In(Labour\ cost)+\beta_4\, In(Seed)+\beta_5 In(Fertilizer)+\ln(otHer\ costs+v_i-u_i \quad (5)$$

$$\mu_i=\delta_0+\delta_1(Experience)+\delta_2(Education)+\delta_3(Farm\ size)+e_i \quad (6)$$

Except for the inefficiency effect variables, all the variables are in their natural logarithm. Education and Experience are farmers' years of formal education and number of years of farming respectively.

Farm size is the size of the farmers' plot in acres, the natural logarithm of which is land. Thus, the variable appears twice in the model as an x-variable as well as a z-variable. This is conventional [21] as the assumption is that it shifts the frontier as well as pushes farmers closer to the frontier.

Equations 5 and 6 were estimated by maximum likelihood, using the computer program, FRONTIER version 4.1 [22]. The maximum likelihood estimation yields consistent estimates of β,δ,γ , and σ_s^2; where $\gamma=\sigma^2/\sigma_s^2$ and $\sigma_s^2=\sigma_v^2+\sigma^2$.

It must be mentioned that even though there have been a number of technical efficiency studies in developing countries [18], there is the need for continuous studies because the determinants of efficiency are time and location-specific, which means that generalizations,

though convenient, may compromise precision and correctness. Also, research develops with time: like the pure scientists, social scientists need to improve upon their research tools in order to cope with the growing complexity of human life. It is in the light of this that this study was carried out to contribute to the already laid down tools used to analyze the levels and determinants of technical efficiency.

2.1 Data and Study Area

Purposive and simple random samplings were used to select a sample of 100 farmers within the Tono Irrigation Project. Purposive sampling was employed to select four out of the nine communities in the study area, while simple random sampling was used to select the 100 individual respondents. The methods of data collection included the administration of semi–structured questionnaires as well as key–informant interviews and personal observation. Even though the data was collected in 2007, the conviction is that the socioeconomic behavior patterns of the people in the study area with respect to the determinants of technical efficiency may not have changed significantly. Tono is the study area in the Kassena-Nankana District of the UER. The ICOUR project manages the Tono irrigation dam. The reservoir is 160m above sea level. The total irrigable land is about 2490ha. The dam was constructed in 1975, and covers a total catchment area of 3600ha with a developed irrigable land of 2400ha. There are nine communities that live and farm at the Tono project area. The people are predominantly farmers. Economic activities that provide lucrative jobs are few and as such most inhabitants engage in dry season gardening. Small irrigated farms, multiple cropping, labour intensive practices and intensive use of inorganic fertilizers characterize production at the ICOUR irrigation project. Appendices 1 is a map of Ghana showing the Upper East region and Appendix 2 a layout of the Tono Irrigation project showing the communities.

2.2 Descriptive Statistics of Variables used in the Model

Table 1 below shows the descriptive statistics of the variables. The average mean output of tomatoes produced during the 2007/2008 farming season by the sampled farmers was 2565 Kg (2.57tons). The mean inputs used were as follows: two acres of farmland; 33Kg of tomato seeds; 150Kg of solid fertilizer; 10 hours of family labour; GH¢ 392 worth of hired labour; and GH¢ 147 worth of other expenses such as irrigation water and liquid fertilizers. Similarly, a typical tomato farmer had 7 years of education (primary) as well as 7 years of experience in tomato production.

Table 1. Descriptive statistics of variables used in the model

Variable	Minimum	Maximum	Mean	Std. deviation
Total output (in Kg)	1000.0	17500.0	2565.0	2353.3
Farm size (in acres)	1.0	3.0	2.0	0.7
Family labour in hours	2.0	21.0	10.2	5.0
Hired labour cost in GH¢	134.0	1000.0	392.1	200.7
Seed (in Kg)	2.0	33.0	13.9	8.2
Fertilizer (in Kg)	0.0	150.0	90.0	48.5
Other costs (in GH¢)	59.0	495.0	147.3	93.3
Experience (in years)	2.0	27.0	7.3	4.7
Education (in years)	0.0	12.0	7.3	4.5

Current Exchange rate: $1= GH¢1.98

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Indicators of Respondents

The survey involved 70% and 30% males and female farmers respectively. Also, 90% of the farmers were married, while 8% and 2% were single and divorced respectively. Furthermore, 78%, as opposed to 22% had formal education. In terms of experience, the majority of the farmers (58%) had been in tomato cultivation for 6-10 years, followed by 38%, who had been in the business for 1-5 years. The remaining 8% had been cultivating the crop for over 10 years. Later in the study it would be found out how some of these indicators influenced the farmers' efficiency.

3.2 The Determinants of Output

From Table 2, it can be observed that among the conventional inputs, land, family labour and seed were significant in determining output, with their expected signs. A 100% increase in land results in 59% increase in output. Similarly, when family labour, seed or other costs increase by 100%, output increases by 19%, 18% and 65% respectively. However, even though hired labour and fertilizer maintained their expected signs they were not significant in determining output. The sum of the coefficients is 1.57, which suggests there is increasing returns to scale in tomato production in the study area.

Technical efficiency estimates for the sampled tomato farmers showed a minimum of 36% and a maximum of 99%. The mean value was 71%, which is comparable with the findings of similar studies. For instance, in Bhasin and Akpalu's [23] study, the mean technical efficiencies of tomatoes, onions and pepper production in the UER are 71, 82 and 88% respectively. Similarly, while [24] finds technical efficiencies of 48% and 45% respectively for adopters and non-adopters of Green revolution technologies, Alhassan [25] finds 48% and 45% respectively for Irrigators of Rice and Non-Irrigators of Rice in Northern Ghana. Lastly, while in Ajibefun and Daramola's [26] study the technical efficiency values for rural and urban small-scale farmers in Nigeria are 66% and 57% respectively, Obwona [27] finds the technical efficiency of tobacco growers in Uganda to be 76%. Clearly, the sampled farmers in our current study were very efficient, and this may be attributed to the high agricultural intensification practices being adopted. In Table 3 it can be observed that the modal class is 0.91-1.00 with a frequency of 24 which buttresses the fact that the farmers were generally efficient.

The estimated gamma parameter of 0.13 in the study area means that the variation in output was due to a small percentage of the technical inefficiency, implying that a greater percentage was due to random shocks outside the farmers' control. This is quite understandable considering the fact that agriculture in the study area is very risky. The estimated sigma squared(σ^2) of 1.0 is significantly different from zero which implies a good fit and the correctness of the specified distributional assumption.

Table 2. Maximum likelihood estimation results of the stochastic frontier model

Variables	Parameter	Coefficient	Standard error	T-test
Stochastic frontier				
Constant	β_0	-0.96	0.81	-1.18
Land	β_1	0.59	0.25	2.31**
Family labour	β_2	0.19	0.11	1.78*
Labour cost	β_3	0.08	0.08	0.97
Seed	β_4	0.18	0.11	1.63*
Fertilizer	β_5	-0.12	0.14	-0.83
Other costs	β_6	0.65	0.11	5.72***
Inefficiency model				
Constant	δ_0	-0.56	0.39	-1.41
Experience of farmer	δ_1	-0.05	0.02	-2.09*
Education of farmer	δ_2	-0.02	0.01	-2.00
Farm size of farmer	δ_3	0.53	0.22	2.45*
Variance of parameters				
Sigma square	σ^2	0.10	0.02	4.05***
Gamma	γ	0.13	0.30	0.45
Log-likelihood function	-	-11.20		
Mean Efficiency	-	0.71		

*Where: ***, significant at 1% **significant at 5% and * significant at 10%. Note: Dependent variables of stochastic frontier model and the inefficiency model are log of the total value of crop output and efficiency levels respectively.*

Table 3. Frequency distribution of technical efficiency scores

Class interval	Frequency	Percentage
0.31-0.40	6	6
0.41-0.50	14	14
0.51-0.60	18	18
0.61-0.70	6	6
0.71-0.80	6	6
0.81-0.90	16	16
0.91-1.00	24	24
Total	100	100

Mean value=0.71; Minimum value=036; maximum value=0.99; standard deviation=0.2

3.3 Socio-Economic Determinants of Inefficiency

At this stage, the socio-economic factors that explain the technical inefficiency of the sampled farmers are explained. It must be noted that in the inefficiency effect model the explanatory variables are determinants of inefficiency and not efficiency. This means that a variable with a negative coefficient has a negative relation with inefficiency but a positive relation with efficiency. The opposite is the case for a variable with a positive coefficient. From Table 2 above all the socioeconomic variables were significant in determining technical efficiency in the study area. However, while farmers' level of formal education and years of farming experience each positively affected their technical efficiency (or negatively affected their inefficiency), farm size negatively influenced their efficiency (or positively affected their inefficiency). Education is an important determinant of the efficiency of farmers as it equips one with knowledge in the discretional use of modern technology, farm organization, and optimal utilization of farm inputs which raises efficiency. This finding confirms that of [25]

who stresses that education enables farmers to understand the social and economic conditions governing their farming activities and thereby increasing their output. In [23] study, education positively influences the efficiency of tomato farmers, but not pepper and onion farmers in the Upper East Region. However, researchers [24, 32] find farmers' educational background not significant in determining their efficiency.

Similarly, in [25] study, farming experience is positively related to technical efficiency for non-irrigators of rice. He intimated that with accumulated experience, farmers effectively mobilize and use family labour and appropriately keep records.

Figs. 2-6 below further explain the relationship between technical efficiency and the socioeconomic variables. For instance, Fig. 2 shows that technical efficiency for males was greater than that of females and from Fig. 3, farmers who had formal education had higher technical efficiency than their counterparts who had no formal education. Technical efficiency was also greater for: farmers with smaller number of family size (Fig. 4); farmers with more than five years of farming experience (Fig. 5); and farms that were greater than two acres as opposed to those that were two acres or less (Fig. 6).

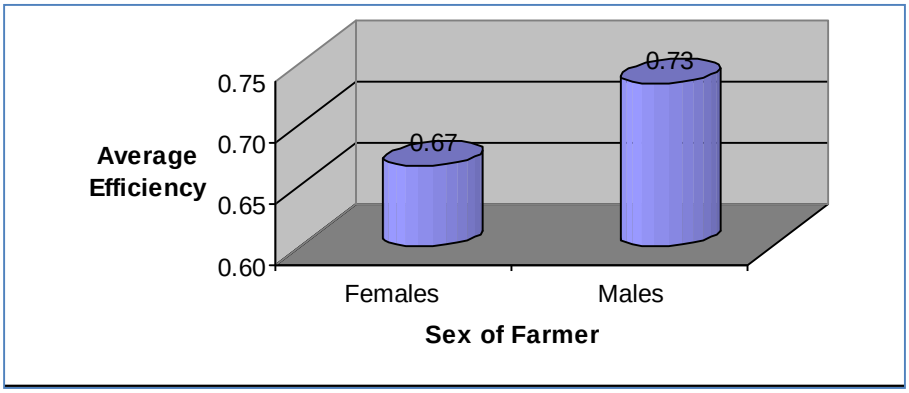

Fig. 2. Gender and average efficiency

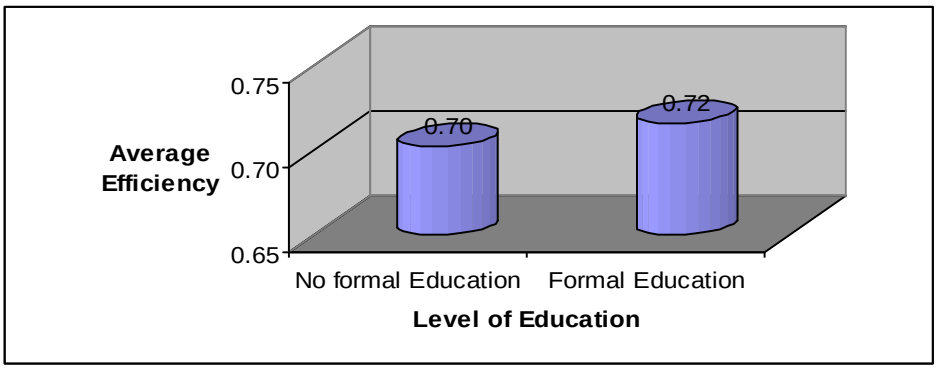

Fig. 3. Farmers' level of education and average efficiency

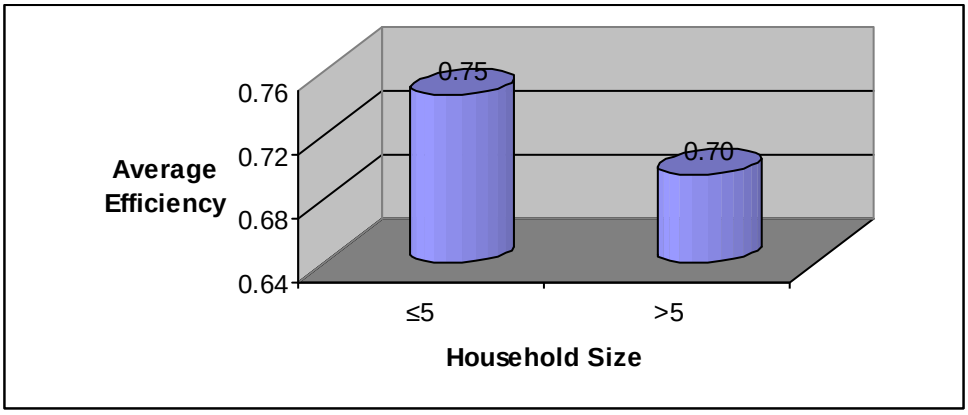

Fig. 4. Household size and average efficiency

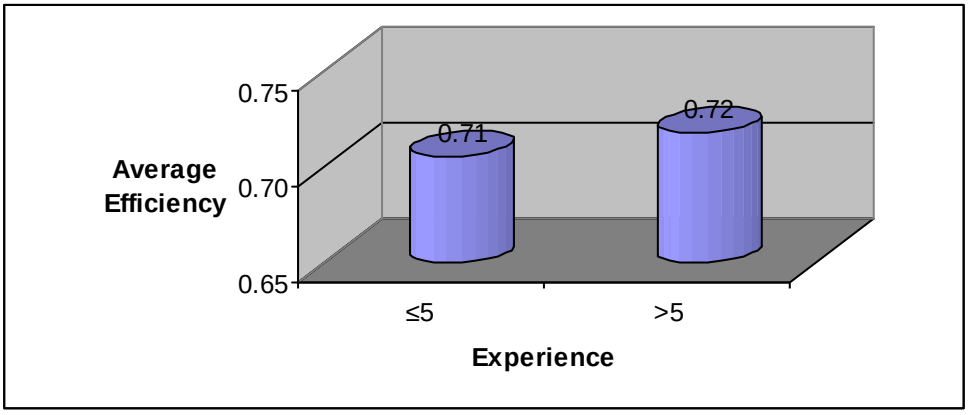

Fig. 5. Famers' experience and average efficiency

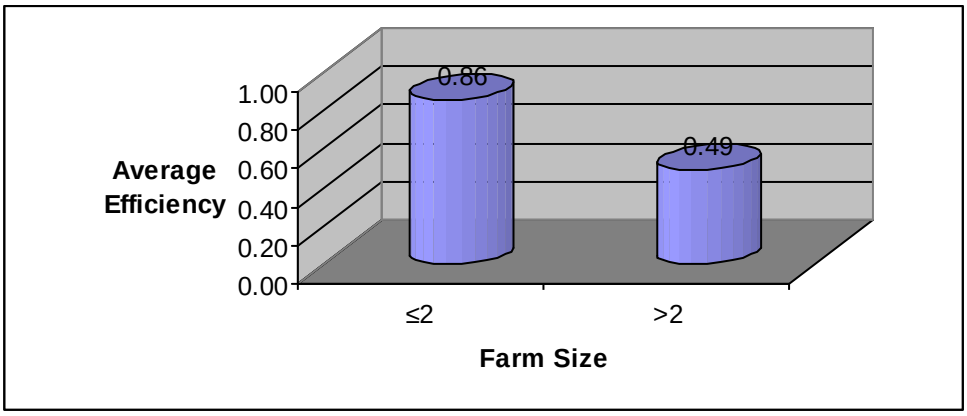

Fig. 6. Farm size and average efficiency of farmers

3.4 Farmers' Perceptions on the Effects of Tomato Importation

As indicated earlier, another objective of the study was to find our respondents' views about the effects of and solutions to tomato importation into the country. From Table 4 below, the most identified effect was the fact that it drives local farmers out of production, and hence limits the scale of domestic production (31%). The second most identified effect of tomato importation was raising unemployment levels and the consequent reduction of the farmers' standards of living (24%). Other effects were: the reduction of the sale of local tomatoes leading to losses (22%); food insecurity (17%) and psychological problems, leading to self-poisoning and deaths (6%).

Table 4. Frequency distribution of the effects of tomato importation

Effect	Frequency	%
Drives farmers out of production/affects scale of production/Kills farmers motivation/ Harvest losses	62	31
Affects marketing local tomatoes drastically/running at a loss/increase production cost	44	22
Food insecurity	34	17
Affects living standards/heightens poverty/threatens livelihood of farmers/ Raises unemployment levels	48	24
Psychological problems/Loss of lives/self poisoning	12	6
Total	200	100

3.5 Farmers' Perceptions on the Solutions to the Effects of Tomato Importation

In Table 5, the solutions proposed by the respondents to curb the negative effects of tomato importation are summarized. The most cited solution was a review of the cross border trade between Ghana and her partners, especially the ECOWAS Trade Treaties (20.4%), followed by the subsidization of tomato production locally (15.5%), re-establishment of the Pwalugu tomato factory (4.9%), farmers' cooperative formation (3.5%) and guaranteed price for tomatoes (2.1%).

Table 5. Frequency distribution of solutions to the effects of tomato importation

Solution	Frequency	Percentage
Re-establishment of Pwalugu tomato factory	14	4.9
Government subsidization/provision of inputs/provision of credit	44	15.5
Restriction of cross border trade/Govt to halt importation/review of cross border relations, and trade/Gov't and NGOS interventions in marketing of tomatoes/Gov't to prevent Ashanti women from crossing to Burkina to buy tomatoes/Revision of ECOWAS Trade Treaties	58	20.4
Better price offers for tomato/proper negotiable prices	6	2.1
Farmers' Cooperative formation	10	3.5
Patronage in Ghanaian tomatoes	2	0.7
Negotiating production times with Burkinabe farmers	2	0.7
Better storage facilities	4	1.4
Provision of market centres for tomato farmers	2	0.7
Total	284	100

3.6 Policy Implications

There are two main interrelated issues that emerge from the findings of this study. The first is that agricultural intensification has great potential in raising output levels. Secondly, the increased output is not an end in itself; farmers' ultimate aim for cultivating a cash crop like tomato is to realize increased revenue. In the case of the former, the policy implication is that agricultural intensification should be promoted. Population pressure, which is one of the factors necessitating agricultural intensification, is a reality in Africa, despite the perception that the continent is endowed with vast stretch of arable land. Land at ICOUR is scarce; the average size is 1.5 acres. The fact that the dam has a limited catchment area means that dry season farming cannot be practised everywhere. There is the need for support in a sustainable manner, not only in the maintenance of the dam, but also in the acquisition of inputs such as seeds, tractor services and liquid fertilizers.

As indicated earlier, FASDEP I was meant to provide a framework for modernizing the agricultural sector and making it a catalyst for rural development in accordance with the goal set for the sector in the GPRS1. However, MoFA [8] was quick to admit that the policies were not able to make the desired impact on poverty. For instance, it was anticipated that smallholder agriculture could be modernized, but this was not possible because the poor were not well-targeted in the document. In an environment of limited resources and fierce competition from large-scale farmers locally and internationally, it is necessary for small-scale farmers to be well targeted (in terms of access to credit, technology, infrastructure and markets, among others). The inability to properly target them meant that modernization was going to be a mirage. Similarly, in FASDEP I, the process by which MoFA was to stimulate response from other MDAs for interventions that fell outside the domain of MoFA was not specified. It was against this background that FASDEP II was formulated, with seven thematic areas based on FASDEP I as follows: human resource development; technology development and dissemination; infrastructure development; promotion of specific commodities for markets; improved financial services; cross-cutting issues (e.g. gender and land) and implementation framework. FASDEP II makes quite a good diagnosis of the issues and strategies relating to agriculture in Ghana. The concern, however, has been whether this

is not another policy document that is only good for the shelf. [28] notes that "even though FASDEP II fully recognizes that the challenge of implementation has been the primary cause of past unsuccessful attempts, it does not include a ranking of priorities, a clear mapping of results and responsibilities to itself and other Government agencies, and a time line for all the priority actions." If the strategies that are designed in FASDEP II are followed to the letter it should help alleviate a lot of the farmers' problems with respect to accessing the inputs that make agriculture modern.

The second policy implication is that local farmers should also be supported to be able to compete with their foreign competitors. [29] laments that the "underlying causes of poverty and food insecurity in northern region of Ghana are the increasing international competition depressing domestic and external output market prices on the one hand, and on the other, the removal of input subsidies and high inflation in the costs of inputs." Accordingly, Raman [30] reports that despite the important role that the small dams play in raising tomato output in the study area, farmers are not deriving the ultimate benefits of increased incomes, because of the fierce competition from cheap imports from the European market. Similarly, Amikuzuno and Ihle [31] estimate that about 70% of fresh tomato produced in Burkina Faso is sold in Ghana. Unfortunately, as remarked by the farmers "the Ashanti women (middlemen from the Ashanti region) prefer the tomatoes from Burkina to the ones at ICOUR". This has a telling effect on local farmers following the competition they have to face in marketing their locally produced tomato. Also, the Ghanaian populace, especially urban dwellers, is yet to be weaned from consuming imported canned tomatoes. In fact, it is reported that Ghana is Africa's largest importer of tomato concentrate, with annual imports of over 10,000 tones.

In terms of the way forward, the refurbishment of the Pwalugu tomato cannery is in the right direction. The Vice President (now the President)[1] was also reported to have linked the farmers to a tomato buying company in Accra, which means that the situation is not as bad as it used to be. However, more needs to be done; the recommendations made by the respondents in this current study are crucial, especially, the one on the review of the cross border trade between Ghana and her partners. If this is politically incorrect, then the Ghana government may also have to further subsidize tomato production, as suggested by the farmers, so that they can also sell at competitive prices. Ghanaians must also be encouraged to patronise the locally produced foods. However, the farmers also have a part to play by cultivating the varieties desired by consumers. Furthermore, they must form cooperatives, as they themselves mentioned, to have a strong bargaining power. Having a strong bargaining power may not be the only gain from the cooperative movements; farmers would have the opportunity of learning from more experienced colleagues, who per the results of this study are more technically efficient.

4. CONCLUSION

The main objective of the study was to find out the technical efficiency levels of tomato farmers at the Tono Irrigation Project in the UER of Ghana. The study also sought to find out farmers' opinions about the effects of the importation of tomato into the Ghanaian economy and the way out of the problem. The method of analysis involved one-step estimation of the Cobb-Douglas stochastic frontier model. The technical efficiency levels ranged from 0.36 and 0.99, with a mean value of 0.71. The most identified effect of tomato importation into the

[1] The Vice President (John Mahama) was sworn in as President on July 24, 2012 following the death of President Atta Mills.

Ghanaian economy was the fact that it drives local farmers out of production, and hence limits the scale of domestic production (31%). The second effect was raising unemployment levels and the consequent reduction of the farmers' standards of living (48%). Other effects were: the reduction of the sale of local tomatoes leading to losses (44%); food insecurity (34%) and psychological problems, leading to self-poisoning and deaths (12%). In terms of the way out of the tomato importation, the most cited solution was a review of the cross border trade between Ghana and her partners, especially the ECOWAS Trade Treaties (58%), followed by the subsidization of tomato production locally (44%), re-establishment of the Pwalugu tomato production (14%), farmers' cooperative formation (10%) and guaranteed price for tomatoes (6%). In conclusion, it can be said that the relatively high agricultural intensification practices at the Tono Irrigation sites mainly explains the high technical efficiency levels of the tomato farmers. However, for the farmers to enjoy the full benefits of their labour they need to be supported to be able to sell their produce at competitive prices like their foreign counterparts. A panel study may be carried out to understand the long term effects of the determinants of technical efficiency in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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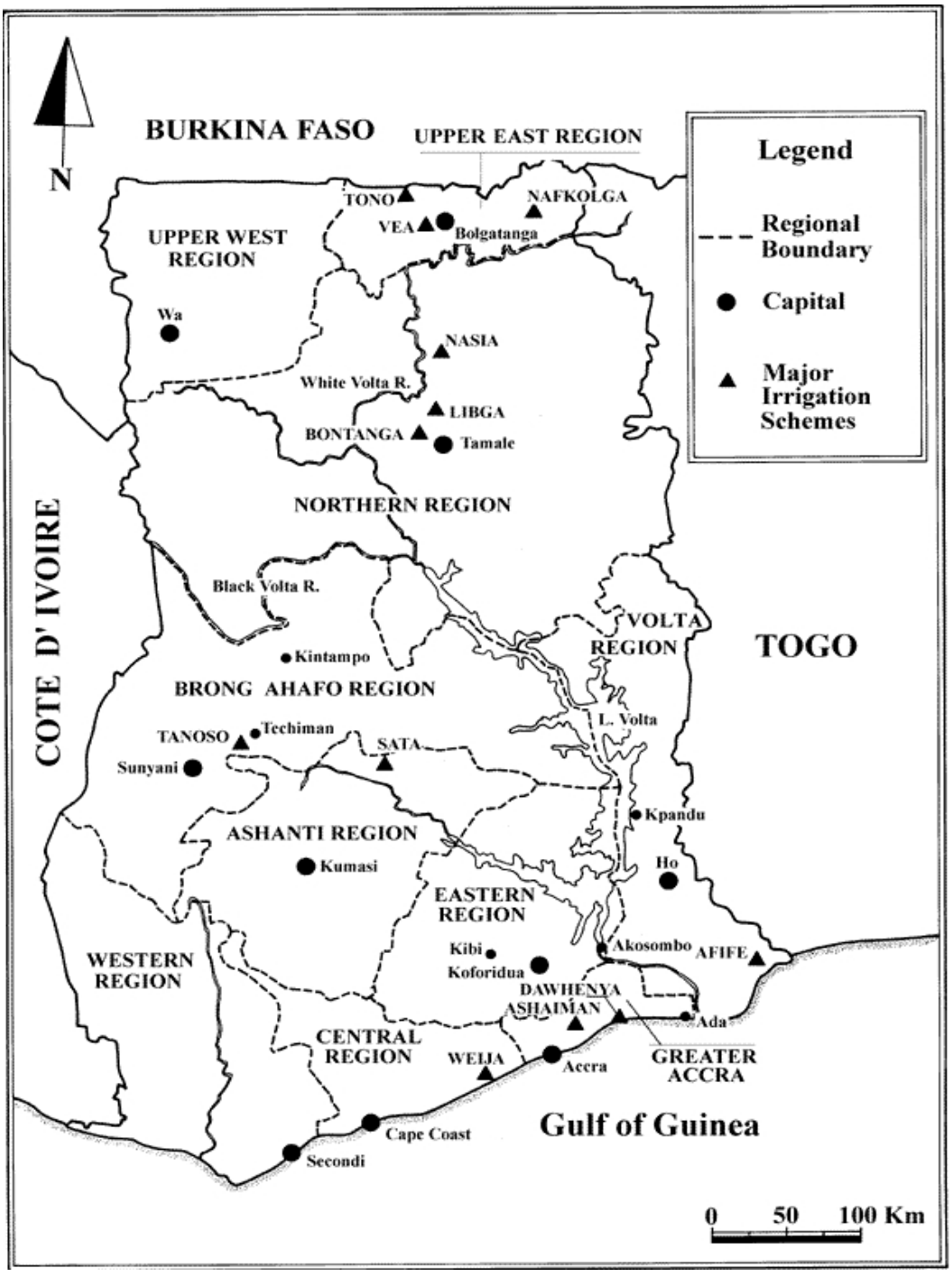
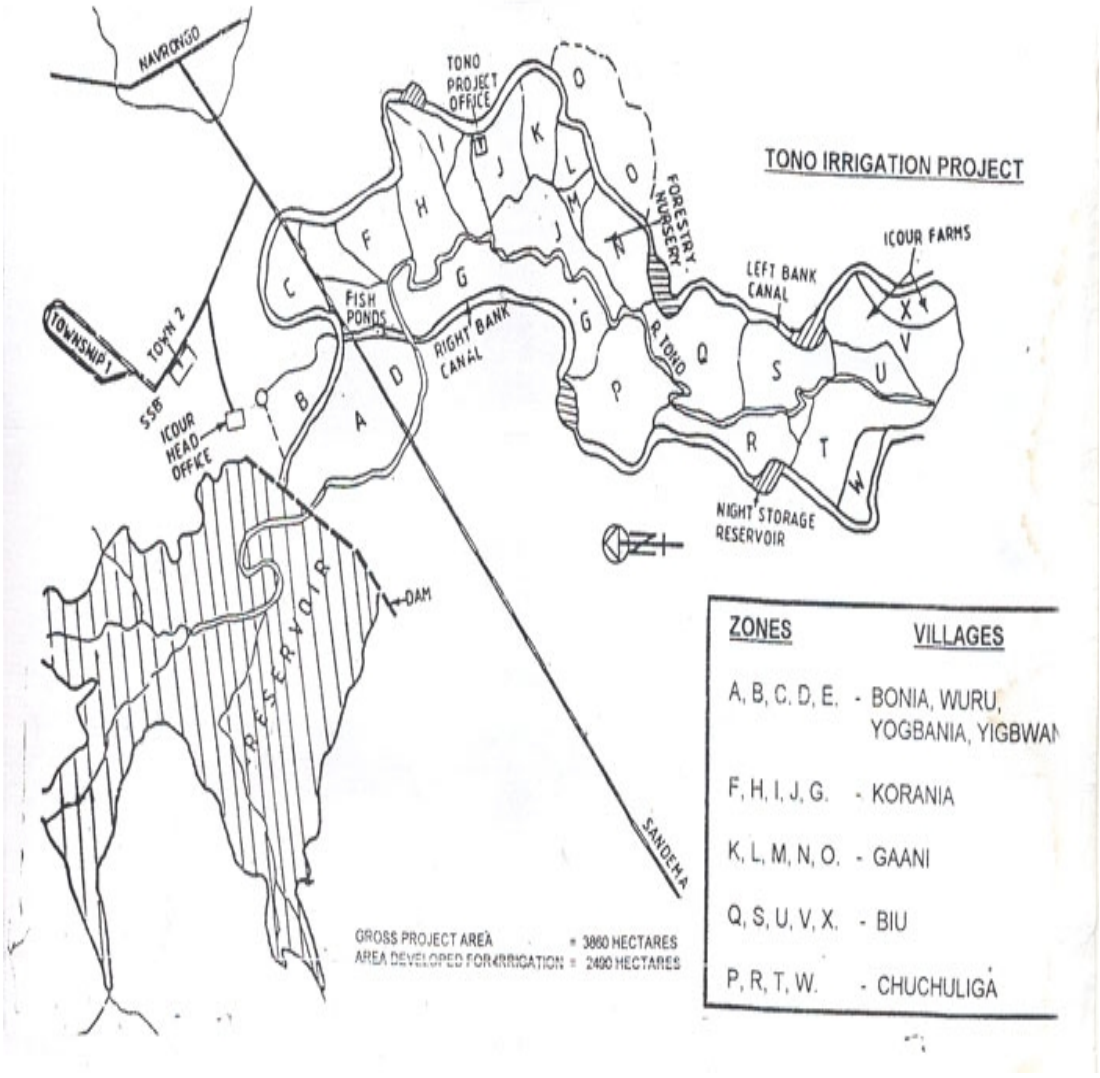
APPENDIX 1

A map of Ghana showing the major irrigation schemes including Tono



APPENDIX 2

A layout of the Tono irrigation scheme



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