

ESTIMATING TECHNICAL EFFICIENCY OF TOMATO PRODUCTION IN NORTHERN GHANA

Donkoh, S. A^{1*}, Tachege M¹. and Amowine, N¹.

¹Department of Agricultural and Resource Economics, Faculty of Agriculture, University for
Development Studies, Tamale, Ghana

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

* Tel.: (+233) (0)245728465; E-mail address: sammidonkoh@yahoo.com

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*

1. INTRODUCTION

Norton et al. 2010 observe that 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 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. Norton et al (2010) 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, a tomato is one of the most important income-generating vegetables cultivated in Ghana. The crop is cultivated continuously throughout the year because apart

38 from the rain-fed system that normally spans between June and November in the southern
39 part of the country, there is the dry-season system between October and April mainly in the
40 north (especially in the upper east). In 2008, the total tomato cropped area was 16,130
41 hectares, and the estimated production was 284, 000 metric tons. Thus, the crop yield was
42 17.6 metric tons. In 2010 however, production level rose to 35,000 metric tons, valuing
43 \$129,347,000 (FAO, 2012).

44

45 In 2007, a Ghanaian newspaper ran a headline, following the disclosure by parliamentarians
46 from northern Ghana, to the effect that suicide attempts through self poisoning were on the
47 increase in the three northern regions, especially the upper east (Mari and Knottnerus,
48 2007). The reason for the suicide attempts was that some farmers were frustrated because
49 they incurred huge debts as a result of poor marketing of their produce during the season in
50 question. The news item did not come as a surprise to many, because a casual observation
51 along the Tamale-Bolgatanga road during the tomato season reveals dozens of crates of
52 tomatoes along the road with their owners literally begging the market women from the south
53 of the country to buy them. This was the initial motivation for the study; to find out the extent
54 to which the farmers were efficient in their farming business, and the possible determinants
55 of such efficiency, as well as the marketing challenges facing them.

56

57 **Background to the Economy of Ghana**

58

59 Ghana is located on the West African gulf of guinea, 5 degrees, 36 minutes north of the
60 equator and 0 degree; 10 minutes east. Half of the country lies less than 152 meters (500ft)
61 above sea level, and the highest point is 883 meters (2,900ft). The country is bounded in
62 the east by Togo, the west by Cote d'Ivoire and in the north by Burkina Faso. It covers a
63 total area of 238,540 km². Formed from the merger of the British colony of the gold coast
64 and the Togolese trust territory, Ghana in 1957 became the first SSA country in colonial

65 Africa to gain independence. At the early stages of independence, Ghana's economy was
66 among the strongest in the then middle income countries. However, Ghana had been a less
67 developed country until 2010, when a rebasing of the economy (at constant 2006 prices) put
68 the country at a middle income level. The population of Ghana as at 2010 stood at 24.4
69 million with an annual growth rate of 2.4%. Gross domestic product (GDP) as at 2010 was
70 32.3 billion us dollars with a growth rate of 7.7%. The per capita income was 1,325. In 2008,
71 GDP grew by 7.3% and 7.7% in 2010. Until 2010, the agricultural sector remained the
72 highest contribution to GDP and employment. However, with the rebasing of the economy
73 (at constant 2006 prices) in 2010, the services sector contributed 51.4%, followed by
74 agriculture 29.9% and the industry sector 18.6% (ISSER, 2010).

75

76 It is estimated that on average 90% of the farm holders in Ghana are small scale, 9% are
77 medium scale and 1% large scale with average holdings of 4.2, 21.7 and 57 acres
78 respectively. On the whole, for the entire country the average land holding is about 6.4
79 acres (2.56 hectares) (Gerken et al., 2001). There are two main types of farming in Ghana,
80 namely, the traditional and the modern. The former is more common than the latter. The
81 traditional type of farming is practised mostly by the small scale farmers. While in the past
82 this used to be on purely subsistence level, in recent times it could be partly for cash. The
83 traditional type of farming involves the use of simple tools like cutlasses and hoes for
84 weeding, digging and harvesting, among others. There is little or no use of chemical
85 fertilizers, instead bush fallowing and shifting cultivation are relied upon for the soil fertility
86 maintenance. The use of mechanization is limited, and except in the north, there is no use
87 of animal traction. Household labour is the main source of labour and in some instances
88 group labour is used. The crops grown are mainly tubers, cereals, plantain, legumes and
89 vegetables. The modern type of farming system employs modern methods of farming. It is
90 mostly associated with plantation crops. There is use of farm machinery like tractors for
91 clearing the lands in addition to human labour. The use of farm animals is also common

92 especially in the north. There is also the use of irrigation facilities, high yielding varieties
93 (HYV) seeds, pesticides and also inorganic fertilizers.

94
95 Ghana is divided into ten (10) administrative regions, namely: greater Accra (the national
96 capital), central (the former national capital), eastern, western, Volta, Ashanti, Brong Ahafo,
97 northern, upper east and upper west regions. The southern part of Ghana is generally more
98 developed than the north (OFORI, 2002). For instance, all the headquarters of government
99 ministries as well as the two main international ports are located in the national capital. The
100 further one travels from the greater Accra region, the less the level of development and
101 economic resources.

102 103 **Northern Ghana and the Upper East region**

104
105 Northern Ghana comprises three regions: the upper east region (UER); the upper west
106 region (UWR ;) and the northern region (NR). These regions cover an area extending
107 approximately between lat. 8°N and lat. 11°N. They comprise over 40% of the entire land
108 area of Ghana, but contain about 20% of the national population. The three northern regions
109 are among the poorest in the country. The Ghana living standards survey (2000) reveals that
110 the northern, upper east, upper west, central and western regions have the highest
111 incidence of poverty where more than 50% of people live below the poverty line (i.e. Live on
112 less than 1 US dollar per day) and 30% live below the extreme poverty line (i.e. People living
113 on less than ¼ of a dollar per day).

114
115 The upper east region is located in the north-eastern corner of the country between
116 longitude 0° and 10° west and latitudes 10° 30'N and 11°N. It is bordered to the north by
117 Burkina Faso, the east by the republic of Togo, the west by Sissala in Upper West and the
118 south by West Mamprusi in Northern Region. The land is relatively flat with a few hills to the

119 east and southeast. The total land area is about 8,842 sq km, which constitutes about 2.7
120 per cent of the total land area of the country. The region's soil is "upland soil" mainly
121 developed from granite rocks. It is not only shallow and low in soil fertility, but it is weak with
122 low organic matter content and basically coarse textured. In the valleys, the soils range from
123 sandy candy loams to salty clays. They have higher natural fertility but are more difficult to till
124 and are prone to seasonal water logging and floods. Like northern Ghana in general the
125 upper east region experiences one rainy season from May/June to September/October with
126 mean annual rainfall within this period falling between 800mm and 1100mm. There is
127 however, a long spell of dry season from November to mid February which is characterized
128 by cold, dry and dusty harmattan winds. Humidity is, however, very low making the daytime
129 temperature comfortable. The natural vegetation of the region is the savannah woodland
130 characterized by short scattered drought-resistant trees and grass. Agriculture is one of the
131 main economic activities in the region. About eighty percent of the economically active
132 population engages in agriculture. The main produce are millet, guinea-corn, maize,
133 groundnut, beans, sorghum and dry season tomatoes and onions. Livestock and poultry
134 production are also important. Like northern Ghana in general the harsh climatic conditions
135 of the upper east region are a limiting factor for the region to attract both material resources
136 and human capital. As a consequence industrial activity in the region is relatively low.

137

138 **National Agricultural Policy**

139

140 In Ghana the ministry of food and agriculture (MoFA) is the main ministry responsible for
141 policy and planning for the agriculture sector. In recent years two of the policy documents
142 that MoFA has designed in collaboration with other stakeholders, is the food and agriculture
143 sector development policy (FASDEP I & II). "FASDEP I was designed in 2002 and was
144 "meant to provide a framework for modernising the agricultural sector and making it a
145 catalyst for rural transformation, in line with the goal set for the sector in the Ghana poverty

146 reduction strategy (GPRS I)" (MoFA, 2007; p1). However, a poverty and social impact
147 analysis (PSIA) of FASDEP I, revealed that the policies would not be able to achieve the
148 desired impact on poverty. It was against this backdrop that FASDEP II was designed to
149 provide the conducive atmosphere for all categories of farmers, especially the small scale
150 farmers. Another important document that is of particular relevance to northern Ghana is the
151 savannah accelerated development authority (SADA). It is a government policy initiative
152 aimed at addressing the development gap that exists between northern and southern
153 Ghana. The mandate of SADA is to accelerate the socio-economic development of the
154 savannah belt through strategic investment in resource development. It envisions a "forested
155 north" by 2030 where agricultural production is modernised and oriented towards a larger
156 market. This vision is built on the food and agriculture sector development programme
157 (FASDEP) II document.

158

159 **History of tomato production in Ghana**

160

161 As observed by the third world network (TWN) in Mari and Knottnerus (2007) tomato
162 production has been an important economic activity in Ghana, especially the upper east
163 region, which is the poorest region in Ghana. Tomato production has been undertaken since
164 1960 on a commercial basis, benefiting from government's support. The support includes the
165 establishment of dams and irrigation projects that provide water supply to the farms. One of
166 such projects is the Tono irrigation projects built between 1975 and 1985 and covers a
167 catchments area of 3,600 hectares. There are nine villages living and farming within the
168 project area. About 90% of the people living here are engaged in the production and sale of
169 tomatoes. The establishment of the dam allowed for an all-year cultivation of tomatoes and
170 other crops such as rice, onions and pepper. Another important support from government for
171 the tomato industry was the establishment of three tomato canneries in the country
172 producing tomato paste and puree. These were situated in Pwalugu, in the upper east

173 region, Wenchi, in the Brong Ahafo and Nsawam in the eastern region, but near Accra.
174 These canaries gave a further boost of the tomato industry as they entered into contract
175 farming with most of the farmers, supplying them with inputs and giving them ready markets
176 for their produce. In this way, exploitation by market women from Accra and Kumasi was
177 reduced, if not eliminated. However, the tomato industry received a major blow with the
178 introduction of economic recovery and structural adjustment programmes (ERP/SAP) in the
179 early 1980s when government was forced to privatize state-owned enterprises, including the
180 three canneries. In addition, the deregulation and liberalization programmes meant that trade
181 restrictions were relaxed, resulting in the importation of canned tomatoes, especially from
182 the European Union where production is heavily subsidized. For instance, Ghana's imports
183 of processed tomato preserves from the EU increased by 628% from 3,713 tons to 27,015
184 tonnes between 1993 and 2003. The EU market is not the only source of imported tomatoes
185 in Ghana; in recent times local producers have faced fierce competition also from nearby
186 Burkina Faso.

187

188 **Objectives and justification of the study**

189

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

200

201 **Literature review**

202

203 **Technical, efficiency and allocative efficiencies**

204

205 Kumbhakar and Lovell, (2000) and Coelli et al., (1998) note that even though theoretical
206 literature on productive efficiency started in the 1950s with the work of Koopmans (1951),
207 Debreu (1951) and Shephard (1953), Farrell (1957) was the first to have carried out an
208 empirical study on efficiency. He provided an empirical application to U S agriculture using
209 linear programming.

210

211 Farrell (1957) distinguished between two efficiencies, namely, technical and allocative
212 efficiencies. While technical efficiency reflects the ability of a firm to obtain maximal output
213 from a given set of inputs, allocative efficiency is the ability of a firm to use the inputs to
214 optimal proportions, given their respective prices and the production technology. These two
215 measures are then combined to produce a measure of economic efficiency. Figure 1 below
216 illustrates the types of efficiency as explained by Farrell (1957). A firm operating at m is
217 technically efficient because it is operating on the isoquant $IS - IS'$. However if a firm is
218 operating at n it is not efficient because it is far away from m and indeed the origin 0. In this
219 case the technical inefficiency of the latter may be measured by the distance mn, which is
220 the amount by which the firm's inputs can be proportionally reduced without reducing output.
221 Thus, in a ratio form the technical efficiency (TE) of this firm is measured by
222 $TE_i = OM / ON$ which is equal to $1 - MN / ON$. This implies that technical efficiency will
223 take the value between zero and one. Thus a technical efficiency of one implies the firm is
224 fully efficient (while zero efficiency implies the firm has no technical efficiency). From the
225 diagram the input price ratio may be represented by the slope of the straight line $AS - AS'$.

226 With this, the allocative efficiency (AE) of the firm can also be calculated. At point n the
 227 allocative efficiency is defined as the ratio $AE_i = OP/OM$ since the distance pm
 228 represents the reduction in (production) costs if production were to occur at the allocatively
 229 (and technically) efficient point instead of the technically efficient, but allocatively inefficient
 230 point m. The product of technical efficiency (AE) and allocative efficiency (AE) is
 231 economic efficiency (EE) given as:

$$232 \quad EE = TE_i \times AE_i = (OM/ON) \times (OP/OM) = (OP/ON) \quad (1)$$

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

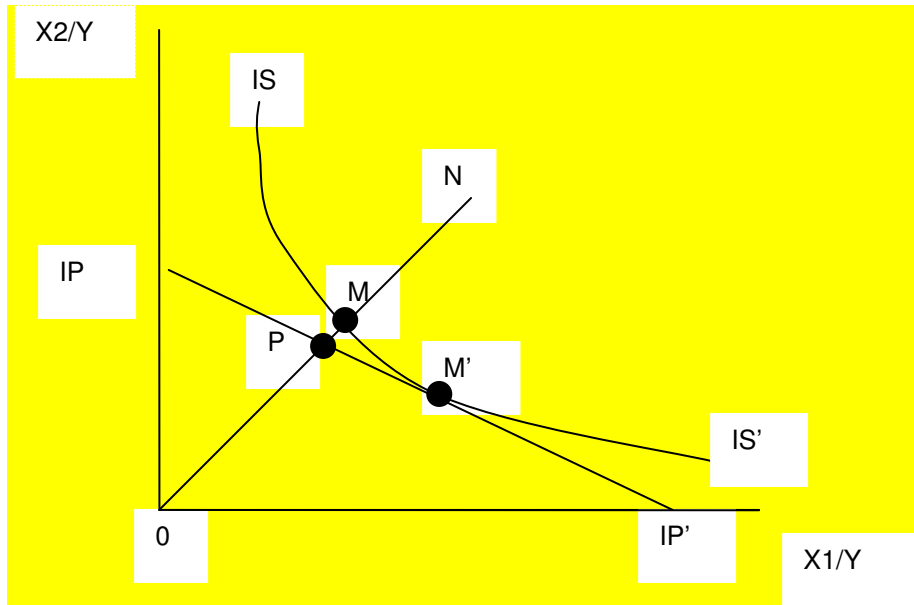
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237

238 Figure 1: Technical, Allocative and Economic Efficiency



239

240 Farrell (1957) argues that in practice it is difficult to estimate a production function because it
 241 is not known. However, it can be estimated from a sample data using either a non-
 242 parametric piece-wise-linear technology or a parametric function such as the Cobb-Douglas
 243 functional form. Charnes et al (1978) took up the former suggestion resulting in what has
 244 now come to be known as the data envelopment analysis (DEA) approach. The latter was
 245 taken up by Aigner and Chu (1968), Aigner et al (1977) and Battese and Coelli's (1992, 1993
 246 and 1995), subsequently resulting in the development of the stochastic frontier analysis
 247 (SFA). The evolution of efficiency studies and the stochastic frontier model is discussed in
 248 detail in Kumbhakar and Lovell, (2000) and Coelli et al., (1998).

249

250 Battese and coelli's (1995) stochastic frontier model (for cross sectional data) is specified as

251

$$252 \quad \ln(y_i) = f(x_i; \beta) + v_i - u_i \quad (2)$$

$$253 \quad \mu_i = z_i' \delta + e_i \quad (3)$$

254 Where:

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

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

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

258 $\ln$ is natural logarithm.

259 Also, while v_i measures the random variation in output (Y_i) due to factors outside the
260 control of the farm firm such as weather and natural disasters, u_i on measures the factors
261 (within the control of the firm) responsible for that firm’s inefficiency such as mismanagement
262 education and experience. v_i is assumed to be identically and independently distributed
263 as $N(0, \sigma_v^2)$ random variables, independent of which is distributed as a truncated normal
264 (at zero) of the $N(\mu_i, \sigma^2)$ distributions. Note that is independently, but not identically
265 distributed; in general, $\varepsilon_i = v_i - u_i$ is the composed error term.

266

267 Furthermore, π_i is a $(k \times 1)$ vector of socioeconomic factors affecting efficiency; δ is a

268 $(1 \times k)$ scalar parameters to be estimated and e_i is a two sided error term with $N(0, \sigma_{e_2}^2)$.

269 The other variables are as defined above.

270 From equation 2, TE can be estimated as:

271
$$TE = \frac{y_i}{\hat{y}_i} = \frac{f(x_i, \beta) e^{v_i - u_i}}{f(x_i, \beta) e^{u_i}} = e^{-u_i} \text{ (so that } 0 \leq TE \leq 1 \text{)} \quad (4)$$

Thus as implied from figure 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 log-likelihood function with respect to the different parameters of the model is presented in the appendix in Battese and Coelli (1993).

The variance parameters are given as $\sigma_{\varepsilon}^2 = \sigma_v^2 + \sigma^2$, where $\gamma = \sigma^2 / \sigma_{\varepsilon}^2$. Note also that $(0 \leq \gamma \leq 1)$.

279

280 2. METHODOLOGY

281

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

284

$$\ln(Y_i) = \beta_0 + \beta_1 \ln(\text{land}_i) + \beta_2 \ln(\text{Family labour}_i) + \beta_3 \ln(\text{Labour cost}_i) + \beta_4 \ln(\text{Seed}_i) + \beta_5 \ln(\text{Fertilizer}_i) + \ln(\text{other costs}_i + v_i - u_i) \quad (5)$$

$$u_i = \delta_0 + \delta_1(\text{Experience}_i) + \delta_2(\text{Education}_i) + \delta_3(\text{Farm size}_i) + e_i \quad (6)$$

288

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.

292

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 (see Coelli et al 1998; p.214) as the assumption is that it shifts the frontier as well as pushes farmers closer to the frontier.

297

298 Equations 5 and 6 were estimated by maximum likelihood, using the computer program,
299 FRONTIER version 4.1 (Coelli, 1996). The maximum likelihood estimation yields consistent
300 estimators for β, δ, γ , and σ_u^2 ; where $\gamma = \sigma^2 / \sigma_u^2$ and $\sigma_u^2 = \sigma_v^2 + \sigma^2$.

301

302 It must be mentioned that even though there have been a number of technical efficiency
303 studies in developing countries (see Battese and Coelli (1992), there is the need for
304 continuous studies because the determinants of efficiency are time and location-specific,
305 which means that generalizations, though convenient, may compromise precision and
306 correctness. Also, research develops with time: like the pure scientists, social scientists
307 need to improve upon their research tools in order to cope with the growing complexity of
308 human life. It is in the light of this that this study was carried out to contribute to the already
309 laid down tools used to analyze the levels and determinants of technical efficiency.

310

311 2.1 Data and Study Area

312

313 Purposive and simple random samplings were used to select a sample of 100 farmers with
314 the Tono Irrigation Dam. Purposive sampling was employed to select a good number of
315 communities out of the nine communities that would present a good representation of tomato
316 farmers in the scheme, while simple random sampling was used to select the 100 individual
317 respondents. The methods of data collection included the administration of semi-structured
318 questionnaires as well as key-informant interviews and personal observation. Even though
319 the data was collected in 2007, the conviction is that the socioeconomic behaviors patterns
320 of the people in the study area with respect to the determinants of technical efficiency may
321 not have changed significantly. Tono is the study area in the Kassena-Nankana District of
322 the Upper East region. The ICOUR project manages the Tono irrigation dam. The Tono

irrigation project is located 10'45" and 1'00" West of the equator. 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 for the map of Ghana showing the Upper East region and Appendix 2 a layout of the Tono Irrigation project showing the communities).

332

333 **Descriptive Statistics of Variables used in the model**

334

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

342

343 **Table 1. Descriptive Statistics of Variables used in the model**

	Std.			
Variable	Minimum	Maximum	Mean	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 the table below, 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 25% increase in output. Similarly, when family labour, seed or other costs increase by 100%, output increases by 11%. However, even though hired labour

364 and fertilizer maintained their expected signs they were not significant in determining output.
365 The sum of the coefficients is 1.57, which suggests there is increasing returns to scale in
366 tomato production in the study area.

367

368 Technical efficiency estimates for the sampled tomato farmers showed a minimum of 36%
369 and a maximum of 99%. The mean value was 71%, which is comparable with the findings of
370 similar studies. For instance, in Bhasin and Akpalu's (2002) study, the mean technical
371 efficiencies of tomatoes, onions and pepper production in the Upper East Region are 71, 82
372 and 88% respectively. Similarly, while Donkoh (2011) finds technical efficiencies of 48% and
373 45% respectively for adopters and non-adopters of Green revolution technologies, Seidu
374 (2008) finds 48% and 45% respectively for Irrigators of Rice and Non-Irrigators of Rice in
375 Northern Ghana. Lastly, while in Ajibefun et al.'s (2002) study the technical efficiency values
376 for rural and urban small-scale farmers in Nigeria are 66% and 57% respectively, Obwona
377 (2008) finds the technical efficiency of tobacco growers in Uganda to be 76%. Clearly, the
378 sampled farmers in our current study were very efficient, and this may be attributed to the
379 high agricultural intensification practices being adopted. In Table 3 it can be observed that
380 the modal class is 0.91-1.00 with a frequency of 24 which buttresses the fact that the
381 farmers were generally efficient.

382

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

389

390 **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
Farm size	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=0.36; maximum value=0.99; standard deviation=0.2

3.2 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

405 variable with a negative coefficient has a negative relation with inefficiency but a positive
406 relation with efficiency. The opposite is the case for a variable with a positive coefficient.
407 From Table 2 above all the socioeconomic variables were significant in determining technical
408 efficiency in the study area. However, while farmers' level of formal education and years of
409 farming experience each positively affected their technical efficiency (or negatively affected
410 their inefficiency), farm size negatively influenced their efficiency (or positively affected their
411 inefficiency). Education is an important determinant of the efficiency of farmers as it equips
412 one with knowledge in the discretionary use of modern technology, farm organization, and
413 optimal utilization of farm inputs which raises efficiency. This finding confirms that of Seidu
414 (2008) who stresses that education enables farmers to understand the social and economic
415 conditions governing their farming activities and thereby increasing their output. In Bhasin's
416 (2002) study, education positively influences the efficiency of tomato farmers, but not pepper
417 and onion farmers in the Upper East Region. However, Donkoh (2011) and Binam et al
418 (2008) find farmers' educational background not significant in determining their efficiency.

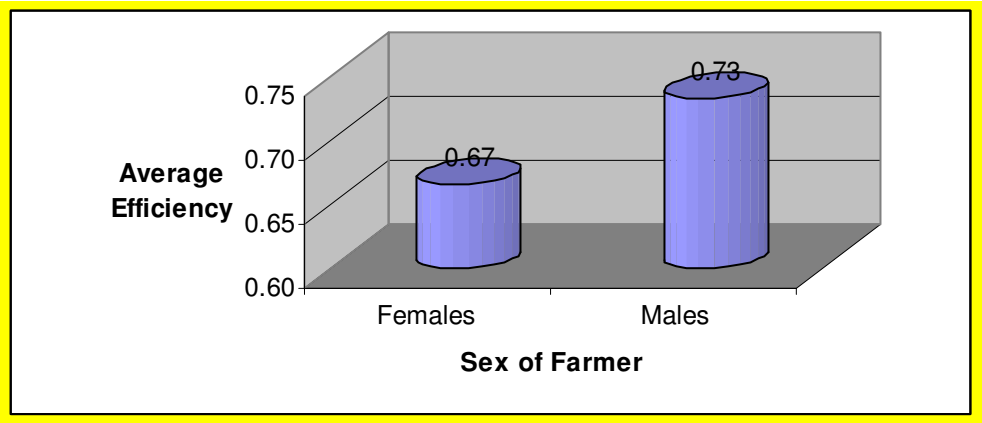
419 Similarly, in Seidu's (2008) study, farming experience is positively related to technical
420 efficiency for non-irrigators of rice. He intimated that with accumulated experience, farmers
421 effectively mobilize and use family labour and appropriately keep records.

422

423 Figures 2-6 below further explains the relationship between technical efficiency and the
424 socioeconomic variables. For instance, Figure 2 shows that farmers with more than five
425 years of farming had average technical efficiency greater than those with five years or less.
426 Also, farms that were greater than two acres had greater efficiency than farms there were
427 less than two acres (Figure 3). Furthermore, technical efficiency was greater for: males as
428 opposed to female famers (Figure 4); farmers with higher formal education, as opposed to
429 those with low or no formal education (Figure 5); and farmers with smaller number of family
430 size (Figure 6).

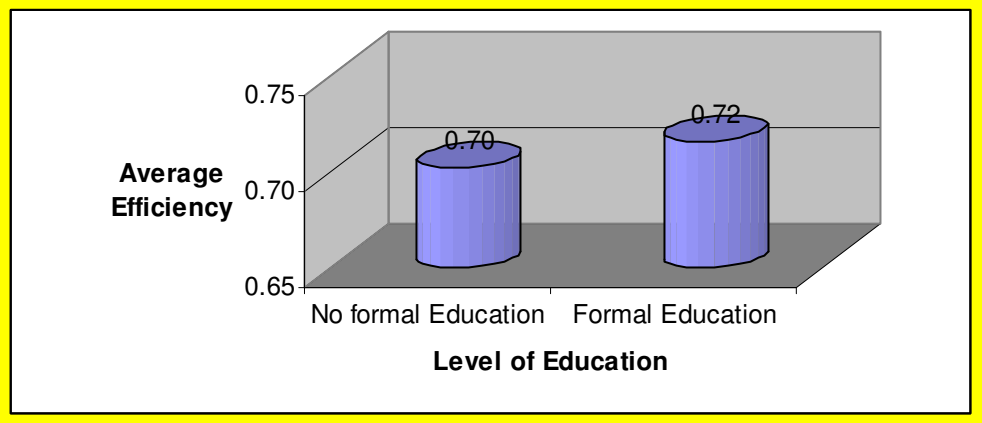
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Figure 2: Gender and average efficiency



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Figure 3: Farmers' level of education and average efficiency



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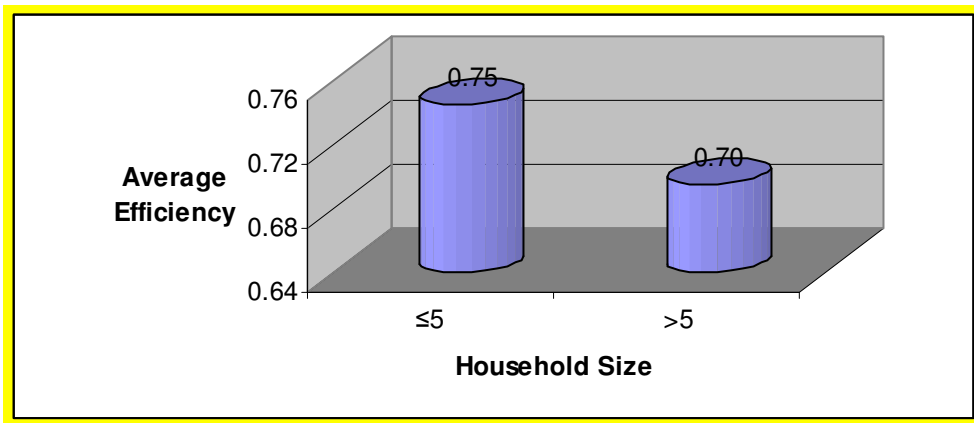
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453 **Figure 4: Household size and average efficiency**

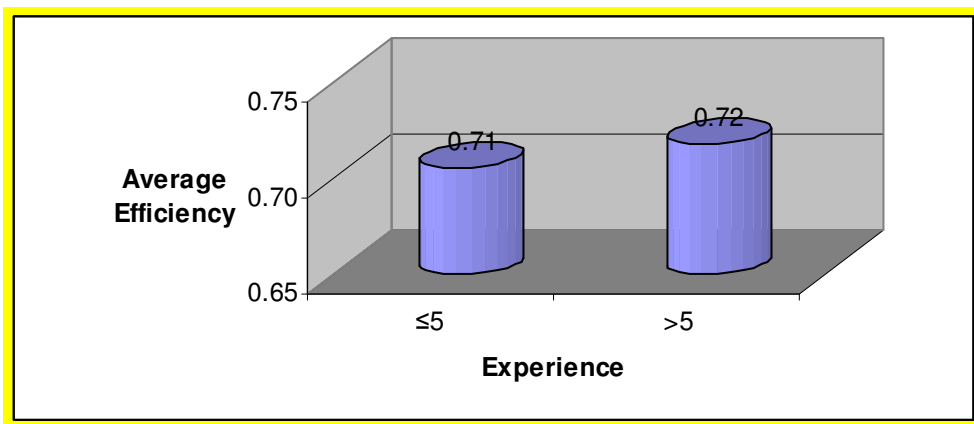


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457 **Figure 5: Famers' experience and average efficiency**



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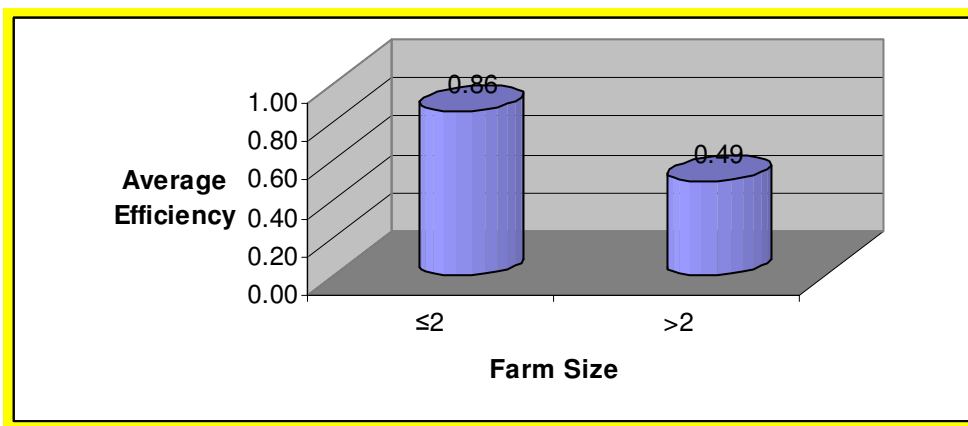
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467 **Figure 6: Farm size and average efficiency of farmers**



468

469

470 **Farmers' perceptions on the effects of tomato importation**

471 As indicated earlier, another objective of the study was to find our respondents' views about
472 the effects of and solutions to tomato importation into the country. From Table 4 below, the
473 most identified effect was the fact that it drives local farmers out of production, and hence
474 limits the scale of domestic production (62%). The second most identified effect of tomato
475 importation was raising unemployment levels and the consequent reduction of the farmers'
476 standards of living (48%). Other effects were: the reduction of the sale of local tomatoes
477 leading to losses (44%); food insecurity (34%) and psychological problems, leading to self-
478 poisoning and deaths (12%).

479

480 **Table 4. Frequency distribution of the effects of tomato importation**

481

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
	200	100

482

483 **Farmers' perceptions on the solutions to the effects of tomato importation**

484 In Table 5, the solutions proposed by the respondents to curb the negative effects of tomato
 485 importation are summarized. The most cited solution was a review of the cross border trade
 486 between Ghana and her partners, especially the ECOWAS Trade Treaties (58%), followed
 487 by the subsidization of tomato production locally (44%), re-establishment of the Pwalugu
 488 tomato production (14%), farmers' cooperative formation (10%) and guaranteed price for
 489 tomatoes (6%).

490

491 **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/gov't 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
	284	100

492

493 **3.3 Policy Implications**

494 There are two main interrelated issues that emerge from the findings of this study. The first
495 is that agricultural intensification has great potential in raising output levels. Secondly, the

496 increased output is not an end in itself; farmers' ultimate aim for cultivating a cash crop like
497 tomato is to realize increased revenue. In the case of the former, the policy implication is that
498 agricultural intensification should be promoted. Population pressure, which is one of the
499 factors necessitating agricultural intensification, is a reality in Africa, despite the perception
500 that the continent is endowed with vast stretch of arable land. Land at ICOUR is scarce; the
501 average size is 1.5 acres. The fact that the dam has a limited catchment area means that dry
502 season farming cannot be practiced everywhere. There is the need for support in a
503 sustainable manner, not only in the maintenance of the dam, but also in the acquisition of
504 inputs such as seeds, tractor services and liquid fertilizers.

505

506 As indicated earlier, FASDEP I was meant to provide a framework for modernizing the
507 agricultural sector and making it a catalyst for rural development in accordance with the goal
508 set for the sector in the GPRS1. However, MoFA (2007) was quick to admit that the policies
509 were not able to make the desired impact on poverty. For instance, it was anticipated that
510 smallholder agriculture could be modernized, but this was not possible because the poor
511 were not well-targeted in the document. In an environment of limited resources and fierce
512 competition from large-scale farmers locally and internationally, it is necessary for small-
513 scale farmers to be well targeted (in terms of access to credit, technology, infrastructure and
514 markets, among others). The inability to properly target them meant that modernization was
515 going to be a mirage. Similarly, in FASDEP I, the process by which MoFA was to stimulate
516 response from other MDAs for interventions that fell outside the domain of MoFA was not
517 specified. It was against this background that FASDEP II was formulated, with seven
518 thematic areas based on FASDEP I as follows: human resource development; technology
519 development and dissemination; infrastructure development; promotion of specific
520 commodities for markets; improved financial services; cross-cutting issues (e.g. gender and
521 land) and implementation framework. FASDEP II makes quite a good diagnosis of the issues
522 and strategies relating to agriculture in Ghana. The concern, however, has been whether this

523 is not another policy document that is only good for the shelf. Nankani (2007, p7) notes that
524 “even though FASDEP II fully recognizes that the challenge of implementation has been the
525 primary cause of past unsuccessful attempts, it does not include a ranking of priorities, a
526 clear mapping of results and responsibilities to itself and other Government agencies, and a
527 time line for all the priority actions.” If the strategies that are designed in FASDEP II are
528 followed to the letter it should help alleviate a lot of the farmers’ problems with respect to
529 accessing the inputs that make agriculture modern.

530

531 The second policy implication is that local farmers should also be supported to be able to
532 compete with their foreign competitors. IFAD (2001.p1) laments that the “underlying causes
533 of poverty and food insecurity in northern region of Ghana are the increasing international
534 competition depressing domestic and external output market prices on the one hand, and on
535 the other, the removal of input subsidies and high inflation in the costs of inputs.”
536 Accordingly, Raman (2007) reports that despite the important role that the small dams were
537 playing in raising tomato output in the study area, farmers were not deriving the ultimate
538 benefits of increased incomes, because of the fierce completion from cheap imports from the
539 European market. Similarly, Amikuzuno and Ihle (2010) estimate that about 70% of fresh
540 tomato produced in Burkina Faso is sold in Ghana. Unfortunately, as remarked by the
541 farmers “the Ashanti women (middlemen from the Ashanti region) prefer the tomatoes from
542 Burkina to the ones at ICOUR”. This has a telling effect on local farmers following the
543 competition they have to face in marketing their locally produced tomato. Also, the Ghanaian
544 populace, especially urban dwellers, is yet to be weaned from consuming imported canned
545 tomatoes. In fact, it is reported that Ghana is Africa’s largest importer of tomato concentrate,
546 with annual imports of over 10,000 tones.

547

548 In terms of the way forward, the refurbishment of the Pwalugu cannery is in the right
549 direction. The Vice President was also reported to have linked the farmers to a tomato

550 buying company in Accra, which means that the situation is not as bad as it used to be.
551 However, more needs to be done; the recommendations made by the respondents in this
552 current study are crucial, especially, the one on the review of the cross border trade between
553 Ghana and her partners. If this is politically incorrect, then the Ghana government may also
554 have to further subsidize tomato production, as suggested by the farmers, so that they can
555 also sell at competitive prices. Ghanaians must also be encouraged to patronise the locally
556 produced foods. However, the farmers also have a part to play by cultivating the varieties
557 desired by consumers. Furthermore, they must form cooperatives, as they themselves
558 mentioned, to have a strong bargaining power. Having a strong bargaining power may not
559 be the only gain from the cooperative movements; farmers would have the opportunity of
560 learning from more experienced colleagues, who per the results of this study are more
561 technically efficient.

562

563 **4. CONCLUSION**

564

565 The main objective of the study was to find out the technical efficiency levels of tomato
566 farmers at the Tono Irrigation Project in the Upper east region of Ghana. The study also
567 sought to find out farmers' opinions about the effects of the importation of tomato into the
568 Ghanaian economy and the way out of the problem. The method of analysis involved one-
569 step estimation of the Cobb-Douglas stochastic frontier model. The technical efficiency
570 levels ranged from 0.36 and 0.99, with a mean value of 0.71. The most identified effect of
571 tomato importation into the Ghanaian economy was the fact that it drives local farmers out of
572 production, and hence limits the scale of domestic production (62%). The second effect was
573 raising unemployment levels and the consequent reduction of the farmers' standards of
574 living (48%). Other effects were: the reduction of the sale of local tomatoes leading to losses
575 (44%); food insecurity (34%) and psychological problems, leading to self-poisoning and
576 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 farmer to enjoy the full benefits of their labour they need to be supported, among others, 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.

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691 **DEFINITIONS, ACRONYMS, ABBREVIATIONS**

692

693 **AE** Allocative Efficiency

694 **ECOWAS** Economic Community of West African States

695 **EE** Economic Efficiency

696 **ERP/SAP** Economic Recovery Programme/Structural Adjustment Programme

697 **EU** European Union

698 **FAO** Food and Agriculture Organization

699 **FASDEP** Food and Agriculture Sector Development Policy

700 **GDP** Gross Domestic Product

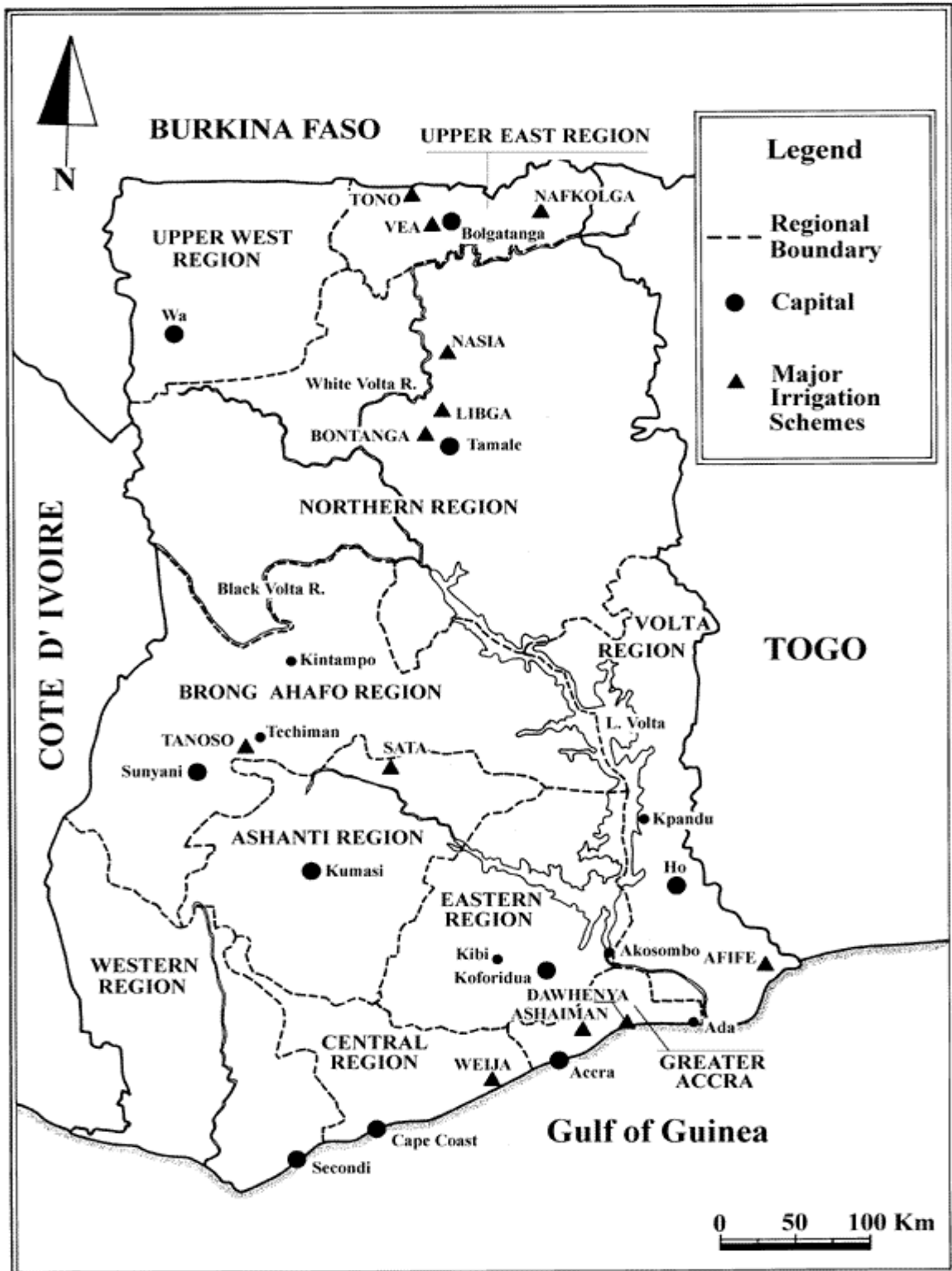
701 **GPRS** Growth and Poverty Reduction Strategy

702 **HYV** High Yielding Varieties

703	ICOUR	Irrigation Company of Upper Region
704	IFAD	International Fund for Agricultural Development
705	MoFA	Ministry of Food and Agriculture
706	MDAs	Ministries, Departments and Agencies
707	SSA	Sub-Saharan Africa (SSA)
708	SADA	Savanna Accelerated Development Authority
709	TE	Technical Efficiency

710 **APPENDIX**

711 Appendix1: A map of Ghana showing the major irrigation schemes including Tono

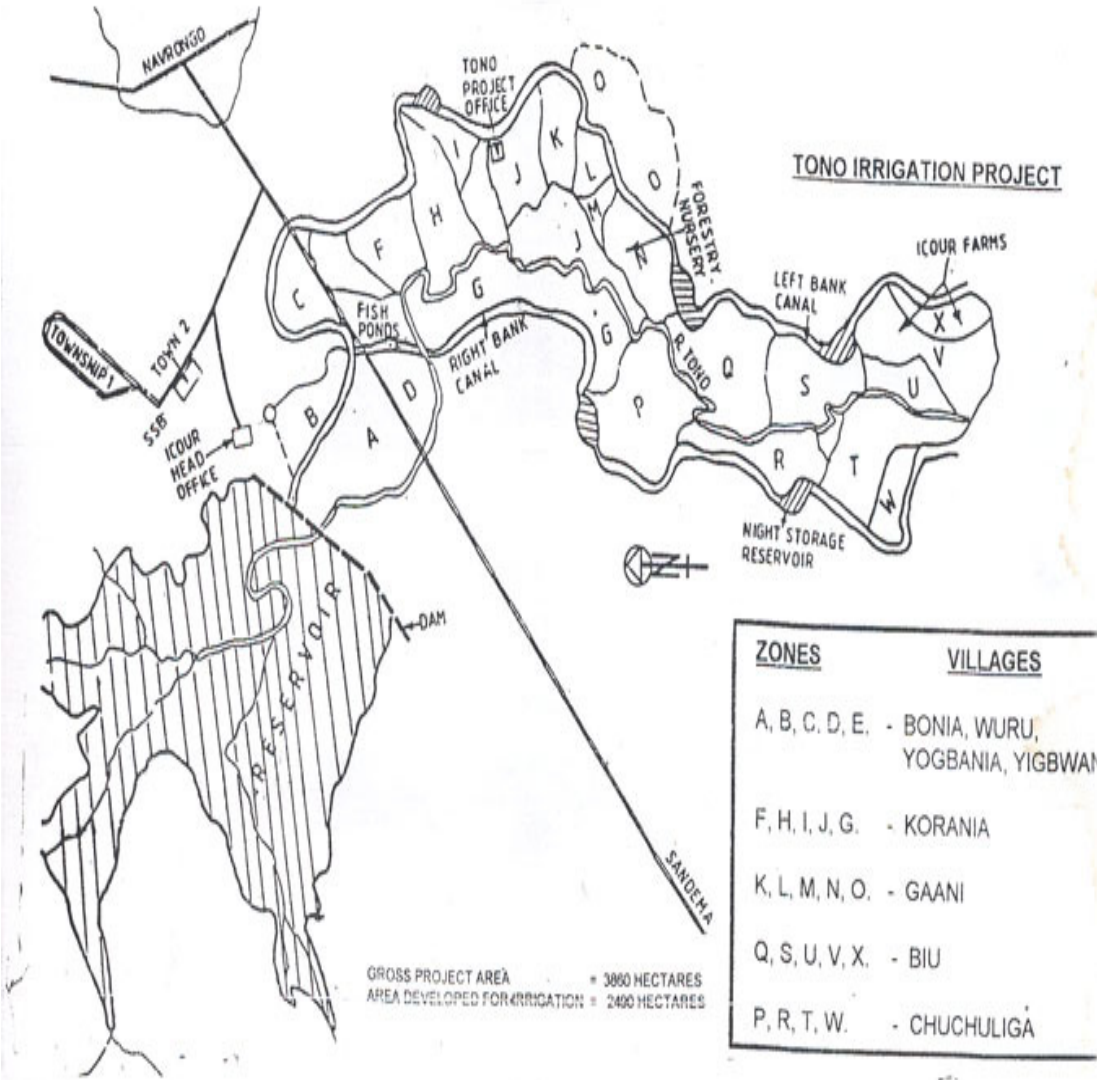


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714 Appendix 2: A layout of the Tono irrigation scheme

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