

TECHNICAL EFFICIENCY OF TOMATO PRODUCTION: THE CASE OF IRRIGATION COMPANY OF UPPER REGION (ICOUR) IN THE KASENA NANKANA DISTRICT OF NORTHERN 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: We used one-step estimation of the Cobb-Douglas Stochastic Frontier Model

Results: We found the mean technical efficiency to be 93%, ranging from 63% and 100%, which shows that tomato farmers at ICOUR were very efficient. This was as a result of the high intensification measures (such as the adoption of modern inputs) that the farmers followed. Factors such as farmers' educational and experience levels were also significant in determining the technical efficiency of the farmers. However, the influx of tomato into the Ghanaian economy was identified as the most serious problem facing the farmers.

Conclusion: While the government must intensify its collaboration with development partners to help with the intensification of tomato production, efforts must be made to get the produce on Ghanaian tables in place of the foreign ones, as a way of motivating the farmers, otherwise attaining the Millennium goal of reducing rural poverty, especially in the Upper East region, will be a mirage.

Keywords: ICOUR, Northern Ghana, Technical Efficiency, Tomato production,

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25 1. INTRODUCTION

26 Meeting the ever growing demand for food remains a major challenge to world agriculture. This is
27 particularly so in Sub-Saharan Africa (SSA) where a majority of the people are poor and food insecure.
28 While hunger and poverty are found in all the regions of the World SSA is the only region where per
29 capita food production has failed to increase since 1980 (Norton et al. 2010). This situation in SSA where
30 agricultural growth is not commensurate with the levels of population growth is a serious one that greatly
31 undermines food and cash security, especially the large population who depend on agriculture for their
32 livelihood.

33 Agriculture in SSA is faced with a number of problems, including land degradation and declining soil
34 fertility. The declining fertility of soils is due to increasing land pressures resulting from rapid population
35 growth. In addition, most soils of humid tropical Africa are sandy, highly weathered, low in organic matter
36 content and susceptible to soil erosion and compaction. The effect is that yields, and for that matter, farm
37 incomes, are low, worsening the poor living standards of farmers. In view of these problems, the present
38 development of agriculture suggests the necessity for significant structural changes requiring good and
39 effective agricultural policies, adoption and full exploitation of technologies and innovations with emphasis
40 on agricultural intensification. Norton et al (2010) intimates that intensive use of land will require improved
41 technologies generated through research as well as improved irrigation systems. Other measures include
42 education and incentives created through changes in institutions such as land tenure systems, input,
43 credit and pricing policies.

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45 Tomato production is one of the most important vegetables in the world, believed to reduce food and cash
46 insecurity. In 2008, China, the world's leading producer recorded the highest production level of over 33.
47 9 million tones followed by the United States, also recording about 13.7 million tones. In SSA, Nigeria
48 recorded the highest production level of 1.7 million. In Ghana, commercial production of tomatoes
49 followed the economic reforms and trade liberalization policy in 1983, and currently, the crop 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).

The tremendous challenge faced by decision-makers, is how to ensure maximum returns to producers through the efficient utilization of farm resources. Agricultural modernization is a priority area of Ghana's Poverty Reduction Strategy (GPRS). The modernization of agriculture implies the development, dissemination, and the adoption of better farming practices. Intensification of agriculture is important in raising the efficiency of farmers for increased output. Tomato farmers are constrained in their efficiency to raise production due to on-farm and off-farm factors. The on-farm factors are those within the control of farmers such as the adoption of modern technologies and the efficient combination of inputs. The off-farm factors are beyond the control of the producers. One of such factors is trade liberalization that has jeopardized the competitiveness of farmers. The challenge of improving the technical efficiency of small-scale farmers for maximum agricultural output raises the need to find out the factors that influence the technical efficiency of tomato farmers at ICOUR.

2. METHOD OF ANALYSIS

A production function is defined as the "maximum output that can be produced from a special set of inputs, given the existing technology available to the firms involved" (Battese, 1992, pp185).

Farrell (1957) proposed that the efficiency of a firm consisted of two components, namely, technical and allocative efficiencies. Technical efficiency reflects the ability of a firm to obtain maximal output from a given set of inputs, and allocative efficiency reflects 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.

The Stochastic Frontier Analysis (SFA) was subsequently developed

In terms of stochastic frontier estimation, Battese and Coelli (1993, 1995) formulations are most appropriate because they make one-step estimation possible to correct for any inconsistencies. Using Battese and Coelli (1995) stochastic frontier model, a Cobb Douglas production function is specified as:

$$Y_i = X_i' \beta + V_i - U_i \quad (1)$$

where Y_i is output of the i th household

X_i is a $(1 \times k)$ vector of farm inputs (in natural logarithm)

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

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. V_i is assumed to be identically and independently distributed as $N(0, \sigma_v^2)$ random variables, independent of U_i which is distributed as a truncated normal (at zero) of the $N(0, \sigma_u^2)$ distributions. U_i is independently, but not identically distributed. In general, $\varepsilon_i = V_i - U_i$ is the composed error term. The Cobb-Douglas production function is simple and has wide application for measuring agricultural productivity.

The technical efficiency of a given firm (at a given time period) is defined by Battese and Coelli (1992) as the ratio of its mean production (conditional on its level of factor inputs and farm effects) to the corresponding mean production if the firm utilizes its levels of inputs most efficiently.

Formally,

$$TE_i = \frac{E((Y_i^* / U_i, X_i))}{E(Y_i^* / U_i = 0, X_i)} = \exp (-U_i) \quad (2)$$

where the numerator is the output of the i^{th} firm and the denominator is the potential output or the average output of all the efficient firms in the same industry as the i^{th} firm.

$$Y_i^* = \exp(Y_i) \quad (3)$$

And TE_i will take a value between zero and one.

Equation 1.1 may take the form

$$\ln(y_i) = f(x_i; \beta) + v_i - u_i \quad (4a)$$

$$u_i = w_i \delta + e_i \quad (4b)$$

Where;

w_i is a vector of independent socio economic variables

δ is a vector of parameters to be estimated and e_i is a two-sided error term with $N(0, \sigma_e^2)$. The other variables are as defined above.

Following from equations 4a and 4b the empirical model that specifies the technical efficiency of tomato farmers at ICOUR is:

$$\begin{aligned} \ln(Y_i) = & \\ & + \beta_1 \ln(\text{Bedpreparation}) + \beta_2 \ln(\text{Tractor services}) + \beta_3 \ln(\text{Transplanting}) + \beta_4 \ln(\text{Fertilizer}) + \\ & \beta_5 \ln(\text{Irrigation}) + v_i + u_i \end{aligned} \quad (5a)$$

$$\mu_i = \delta_0 + \delta_1(\text{Sex}) + \delta_2(\text{Education}) + \delta_3(\text{Experience}) + v_i \quad (5b)$$

Except for the inefficiency effect variables, all the variables are in their natural logarithm. Sex is a dummy variable, which takes the value one (1) if the farmer is a male and zero (0) if female. Education and Experience are farmers' years of formal education and number of years of farming respectively. The main limitation with this study is that cost, rather than physical quantities of the inputs, were used. Data on physical quantities of inputs were scanty. We could not have estimated a cost function too, considering the fact that the study is cross-section, and the per unit costs were homogeneous. Also, farm size should

have been included in the model. It was excluded because it did not vary significantly among the farmers and so it was giving a lot of estimation problems. Other variables that did not vary significantly among the farmers were the number of extension contacts and amount of agricultural credit. Consequently, these variables were excluded from the model.

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

2.1 DATA AND STUDY AREA

Purposive sampling was employed in selecting the communities while simple random sampling was used to obtain 100 individual respondents. Semi-structured questionnaires were used to collect data from the farmers. Tono is the study area in the Kassena-Nankana District of the Upper East region. The study area lies within the Guinea Savanna Zone with an average annual rainfall of 1200mm. Temperatures are generally high, averaging between 25°C to 38°C. ICOUR manages the Tono irrigation dam which is located within 10°45" and 1°00" West of the equator. The reservoir is 160m above sea level. The dam was constructed in 1975 with a total catchment area of 3600ha and a total irrigable land of 2490ha. Economic activities that provide lucrative jobs are few, and as such, most inhabitants engage in dry season gardening, small-irrigated farms and intensive use of chemical fertilizers and pesticides, among others, characterize production at the Tono irrigation dam (see. 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).

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. The categories of years of cultivating tomatoes were as follows: 6-10 (54%); 1-5

(38%); 11-15 (4%); 16-20 (1%); and (21-25) (1%). Later in this section we shall find out how some of these indicators influenced the farmers' efficiency.

3.2 The Determinants of Output

From the table below, all the variables were significant in determining output, maintaining their expected signs. This confirms the assertion that the adoption of modern farm inputs is important in influencing output (Janvry and Sadoulet, 2003; Evenson and Gollin, 2000; Hazell and Ramsamy, 1991). Furthermore, as Donkoh (2011) note, the findings of this present study imply that some level of learning-effects has taken place and that there is some degree of familiarity with modern farm inputs among Ghanaian farming households leading to the adaptation of their traditional methods of production.

Technical efficiency estimates for the sampled tomato farmers show a minimum of 62% and a maximum of 100%. The mean value is 93%, which is far above that of many studies in developing countries. We find that technical efficiencies for studies that centre on agricultural intensification (the use of modern inputs like the present study) are generally higher than that of those that involve traditional agriculture. This is however a 'loose' comparison since technically one cannot compare technical efficiencies across farms this way because the farms may be operating on different frontiers. For instance, in Bhasin's (2002) study, the mean technical efficiencies of tomatoes, onions and pepper production in the Upper East Region are 71, 82 and 88% respectively. Similarly, while Donkoh (2011) finds technical efficiencies of 48% and 45% respectively for adopters and non-adopters of Green revolution technologies, Seidu (2008) finds 48% and 45% respectively for Irrigators of Rice and Non-Irrigators of Rice in Northern Ghana. Lastly, while in Ajibefun et al.'s (2002) study the technical efficiency values for rural and urban small-scale farmers in Nigeria are 66% and 57% respectively, Obwona (2008) 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 (see also Battese (1992).

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173 The estimated gamma parameter of 0.40 in the study area means that 40 % of the total variation in
174 tomato output is due to technical inefficiency. The result suggests that 40 % of the variation in output
175 among farmers is due to differences in technical efficiency and that 60% of the variation in output is due
176 to random shocks outside the farmers' control (Coelli et al, 1998; Dawson and Lingard, 1989). The
177 estimated sigma squared(σ^2) of 1.1 is significantly different from zero which implies a good fit and the
178 correctness of the specified distributional assumption.

179

180 **3.2 Socio-economic Determinants of Inefficiency**

181 At this stage, we turn to the socio-economic factors that explain the technical inefficiency of the sampled
182 farmers. It must be noted that in the inefficiency effect model the explanatory variables are determinants
183 of inefficiency and not efficiency. This means that a variable with a negative coefficient has a negative
184 relation with inefficiency but a positive relation with efficiency. The opposite is the case for a variable with
185 a positive coefficient. From the table above, the sex and education variables have a negative coefficient,
186 which means they have negative effects on inefficiency and positive effects on efficiency, whereas the
187 experience variable of farmers has a positive coefficient which implies a positive effect on inefficiency.
188 Thus, technical efficiency was greater for: males as opposed to female famers; farmers with higher formal
189 education, as opposed to those with low or no formal education; and farmers with smaller number of
190 tomato farming experience. In line with our study, Binam et al (2008) and Donkoh (2011) respectively find
191 male farmers and male-headed households to be more efficient than their female counterparts. Doss and
192 Morris (2001) give the reason for lower efficiency on the part of female-headed households as their
193 engagement in non-farm activities more than their male counterparts. However, Seidu (2008) finds the
194 gender variable not significant in determining technical efficiency.

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196 Education is an important determinant of the efficiency of farmers as it equips one with knowledge in the
197 discretional use of modern technology, farm organization, and optimal utilization of farm inputs which

198 raises efficiency. This finding confirms that of Seidu (2008) who stresses that education enables farmers
 199 to understand the social and economic conditions governing their farming activities and thereby
 200 increasing their output. In Bhasin's (2002) study, education positively influences the efficiency of tomato
 201 farmers, but not pepper and onion farmers in the Upper East Region. Also Donkoh (2011) and Binam et
 202 al (2008) find farmers' educational background not significant in determining their efficiency.

203 The positive sign of the experience variable (meaning a negative effect on efficiency) is contrary to our a
 204 *priori expectations*. However, one explanation often given is that some farmers who have been in farming
 205 for a long time are conservative and are not willing to adopt modern farm practices that would lead to
 206 increased output. In Seidu's (2008) study, farming experience is positively related to technical efficiency
 207 for non-irrigators of rice. He intimated that with accumulated experience, farmers effectively mobilize and
 208 use family labour and appropriately keep records.

209 **Table 1: Maximum likelihood estimator results of the frontier and inefficiency model for the study**
 210 **area**

Variables	Parameter	Coefficient	Standard error	T- test
Stochastic frontier				
Constant	β_0	0.72	0.6	1.2
Nursery bed preparation	β_1	1.71	0.9	1.9*
Tractor	β_2	0.84	0.4	2.1**
Transplanting	β_3	2.34	0.6	3.9**
Fertilizer	β_4	0.9	0.5	1.8*
Irrigation	β_5	2.97	0.3	9.9***
Inefficiency model				
Constant	δ_0	0.16	0.2	0.8

Sex of farmer	δ_1	-0.45	0.3	-1.5
Education of farmer	δ_2	-0.36	0.1	-3.6***
Experience of farmer	δ_3	0.31	0.1	3.1***
Variance of parameters				
Sigma square	σ^2	1.1	0.2	5.5***
Gamma	γ	0.4	0.2	2.0**
Log-likelihood function	-	-0.2	-	-
Mean Efficiency	-	0.93	-	-

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.

3.3 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, if the increased output is to translate into reducing poverty, then it is important that the market is protected for local producers. The policy implication is that agricultural intensification must be supported. 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 practiced everywhere. There is the need for support, not only in the maintenance of the dam, but also in the acquisition of inputs such as fertilizers and tractors, in a sustainable manner.

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 GPRS I (MoFA, 2007).

However, MoFA (2007) 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. Nankani (2007, p7) 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. IFAD (2001.p1) 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 (2007) reports that despite the important role that the small dams were playing in raising tomato output in the study area, farmers were not deriving the ultimate benefits of increased incomes because of the fierce completion from cheap imports from the European market, especially Italy, to the extent that a tomato processing plant that IFAD built in one of their project areas was abandoned, as it was no longer profitable.

The IFAD supported tomato processing plant is not the only plant that northern Ghana has seen. As reported by Raman (2004), in 1968 the Ghana Government built a tomato cannery in Pwalugu in the Upper East region (then the Upper East District), which employed 160 staff, 60 of them permanent. However, with the onset of the Economic Recovery/Structural Adjustment Programme in the eighties, the cannery which was producing about 100 tonnes of tomato concentrate daily was closed down, with a reason of inefficiency. Needless to mention, the closure meant that the farmers no longer had a regular buyer and consequently faced a significant reduction in demand and therefore revenue. In recent times, however, there is a gradual change in policy in the sense that not only has there been a restoration of the fertilizer subsidy, the Pwalugu cannery has been revived and also the vice president has been able to link local producers to a tomato buying company in Accra, which means that the situation is not as bad as it used to be. However, farmers still face competition from Burkinabe imports; According to Amikuzuno and Ihle (2010), 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 2007 it was reported that at least one farmer poisoned himself to death because he did not get market for his tomato produce (see Mari and Kottnerus, 2007). Tomato harvest in that year was so good that farmers were literally begging the market women to buy their produce. The question that was often asked was whether it was justifiable that somebody should suffer for being technically efficient.

4. CONCLUSION

It is morally unfair as a nation for our citizenry to be so disturbed that they would want to commit suicide, simply because they have been efficient in their production. As stated in FASDEP 11 the government of Ghana must be more proactive in raising the incomes of tomato farmers. That is, while increasing its collaboration with development partners to help with the intensification of tomato production, efforts must be made to get the produce on Ghanaian tables in place of the foreign ones, as way of motivating the

farmers, otherwise attaining the Millennium goal of reducing rural poverty, especially in the upper East region, will be a mirage.

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LIST OF ABBREVIATIONS

FASDEP	Food and Agriculture Sector Development Policy
GPRS	Growth and Poverty Reduction Strategy
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)



