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# Estimating Technical Efficiency of Groundnut (*Araches hypogaea* L.) Production in New Halfa Agricultural Production Corporation, Sudan

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**Abstract:** This research study was conducted during season 2006/07 at New Halfa Agricultural Production Corporation (an irrigated Agricultural scheme in Eastern Sudan). To evaluate the technical efficiency of groundnut production by using stochastic frontier production function. The results indicated that the mean production technical efficiency was 70%. This shows that there is a scope for increasing groundnut production by 30%, with the present level of inputs and technology. Also, the result depicted that the irrigation numbers, tenancy location, weeding, labour and farm income were the most important factors that determining production technical efficiency, whereas the extension, agricultural credit had significant effects on tenants' technical inefficiency of groundnut production. To improve groundnut production technical efficiency, the study recommended usage of herbicides, introduce of high yield varieties, cleaning and maintenance of irrigation canals.

**Keywords:** Technical efficiency, Production, Groundnut, Halfa, Sudan.

## 1. Introduction

Groundnut (*Arachis hypogaea L.*) is the sixth most important oilseed crop in the world (El Naim *et al.*, 2010). It contains 48-50% oil, 26- 28% protein and 11-27% carbohydrate, minerals and vitamin (El Naim and Eldouma, 2011; Ibrahim *et al.*, 2013). Groundnut is grown on 26.4 million hectare worldwide with a total production of 37.1 million metric tons and an average productivity of 1.4 metric tons/ha. Developing countries constitute 97% of the global area and 94% of the global production of this crop (Food and Agricultural Organization, 2011). Groundnut is an important oilseed in Sudan, ranks second major oilseed crop grown principally in the irrigated sub-sector (Gezira, New Halfa**,** schemes**),** and in the traditional rain-fed sub-sector (Kordofan, Darfur, White Nile). Groundnut exports accounted for about 0.1% of total Sudan export earnings in the year 2012, this contribution increased to reach 0.6% in the year 2013 (Bank of Sudan, 2013). In New Halfa groundnut is grown as cash crop, beside the oil, seed cake and crop residues used as forage for animals (El Naim *et al.*, 2011).

New Halfa Agricultural Production Corporation (NHAPC) lies on the Eeastern Sudan in the Kassala State between15º-17º longitude; and 35º – 36º latitude it is 360 kilometers east of Khartoum in Sudan. In recent years, the major irrigated schemes have gone down in their operating efficiency, considerable deterioration in productivity and tenant's income has been noticed in general and specially in New Halfa Agricultural Production Corporation (NHAPC). The NHAPC production of Groundunt decreased from 42 thousand metric tons during 1990s to 32 thousand metric tons in 2004/05 season, with a decrease of 23.8% due to a reduction in area harvested from 43 thousand feddan to 30 thousand feddans. Thus, yield dropped from 1200 kg/feddan in 2003/2004 season to 1065 kg/feddan in 2004/05 season. There are various problems behind productivity deterioration in NHAPC, these include, lack of credit, high production cost and low yield (El Naim and Eldouma, 2011).

Production can be increased by increasing the technical efficiency of crops using existing technology. If farmers are found to be technically efficient, production can be increased to a large extent using the existing level of inputs and available technology. Several studies in other countries have shown that there is a significant potential for rising

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agricultural outputs or profitability by improving productive (technical and allocative) efficiency using existing resources. Moreover, these studies have also indicated that there may be significant efficiency differentials between different groups of farms and between different regions among all farms, and it should be possible to improve the performance of the less efficient farms or regions without major investment from outside at least in the short run (Rahman, 2002).

The objectives of this study to estimate technical efficiency of groundnut production and investigate the main factors behind tenants technical inefficiency to improved the production of groundnut.

## 2. Methods and Materials

This study was based on Primary data which collected during the period April to May, 2007 by using a structured questionnaire using Stratified random sampling techniques from 150 respondents, direct personal interviewing was used to fill the questionnaire, before interviewing process the respondents were informed about the purpose of the study in order to gain their confidence.

In order to estimate the level of technical efficiency in a manner consistent with the theory of production function the study used a Cobb-Douglas in its stochastic frontier production function form (Aigner *et al.*, 1977; Battes and Corra, 1977). The form of production function selected has some well-known properties that justify its wide application in economic literature (Rahman, 2002).

### 2.1. Technical Efficiency of Groundnut

The model is written as follows:

$$\text{Ln } y_i = \beta 0 + \sum_{j=1}^{8} \beta_j \text{ Ln } x_{ij} + V_i - U_i$$

where: Ln is the natural logarithm; $Y_i$ is yield of groundnut (sack/ Feddan); $X_1$ is the family size ; $X_2$ is the Tenancy location (1 when tenancy located at head of canal, 2 when tenancy located at the end of canal); $X_3$ is the irrigation number; $X_4$ is the weeding number; $X_5$ is the hired labour ( (manday); $X_6$ is off-farm income (SDG);$X_7$ is the farmer level of education (1 when illiterate, 2 when primary, 3 when secondary, 4 when intermediate and 5 when university) and $X_8$ farm income (SDG); $B_0$ and $B_1$ are regresssion coefficients to be estimated for variables, respectively; $V_i$ represents statistic error and other factors which are beyond the farmers control such as weather, topography and other factors which not included and may be positive, negative or zero. $U_i$ is a non-negative random variable.

### 2.2. Inefficiency Effect Model

The $u_i$ in the stochastic production frontier model is a non-negative random variable, associated with the farmers technical inefficiency in production and assumed to be independently distributed, such that the technical inefficiency effect for the i-th farmers, $u_i$, will be obtained by truncating (at zero) of the normal distribution with mean, $\mu_i$, and variance, $\delta^2$, such that

$$U_i = \delta_0 + \sum_{s=1}^{5} \delta_s Z_{si}$$

Where:

$Z_{1i}$ Experience (number of years spent as a tenant); $Z_{2i}$ extension; (dummy variable which receives 1 if the farm had contact with extension agents and receives 0 if he did not have any contact with extension agents); $Z_{3i}$ Credit **(**dummy variable which has the value of one if the tenant is not constraint by credit and zero, otherwise); $Z_{4i}$ visits (numbers of visits by field inspectors);$Z_{5i}$ Schooling years (years of tenants formal education) and $Z_{6i}$ Animal ownership (dummy variable which receives 1 if the tenant owned animal and zero, otherwise); $\delta_o$ and $\delta s$ coefficient are unknown parameters to be estimated, together with the variance parameters which area expressed in terms of

$$\sigma^2 = \sigma^2 u + \sigma^2 v \text{ and}$$

$$\gamma = \sigma^2 u / \sigma^2$$

Where the $\gamma$-parameter has value between zero and one. The parameters of the stochastic frontier production function model was estimated by the method of maximum likelihood, using the computer program, FRONTIER Version 4.1.

## 3. Results and Discussion

Table 1 shows the estimate of technical efficiency of groundnut production, in New Halfa Agricultural Production Corporation (NHAPC) 2006 – 2007. The mean technical efficiency of groundnut production function is 70% in the NHAPC, with minimum efficiency of 35%, and maximum efficiency 98%. This means that on average, the NHAPC produced 70% of groundnut output that attainable by best practice, given their current level of production inputs and technology used. This implies that the respondent can increase their groundnut output by 30% from a given mix of production inputs if the tenants are technically efficient.

An important result is that the variance ratio parameters $\gamma$ is large and significant and has a value of 0.96. These result express that about 96 % of groundnut output deviation are caused by differences in tenant's level of technical efficiency as opposite to the conventional random variability. The significant estimates of $\gamma$ and $\delta^2$s imply that the assumed distribution of $u_i$ and $V_I$ is accepted.

Table 2 shows the test of hypothesis of groundnut likelihood ratio test (LR), which tests the null hypotheses for the technical inefficiency effect for groundnut production in NHAPC are rejected. The value of the test is calculated as:

$$LR = -2\{\ln[L(H_0) / L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[ L(H_1)]\}$$

Where L $(H_0)$ and L $(H_1)$ are the values of the likelihood function under the null hypothesis and alternative hypothesis, respectively (Ahmed, 2004).

The tenants in NHAPC have a wide range of technical efficiency ranging from 35% up to 98% for groundnut crop. Figure 1 showed that 57% of tenants operate with technical efficiency ranged between (40-80%) and 43% operate with efficiency of (80-100%) this implies that on average, the tenants producing groundnut in NHAPC achieved almost 70% of the potential stochastic frontier groundnut production level given their current level of production inputs and technology used.

Tables 3 and 4 show ML estimates of groundnut production stochastic frontiers and inefficiency effects model for NHAPC. Most of the estimated $\beta$ coefficients of the stochastic frontier model for groundnut production models have the expected sign.

Tenancy location has a negative sign and significant at 5% level of significance for groundnut. A possible explanation of the negative sign is that the tenants who are located at the head of the canal, have a higher yield than those who are at the tail, the same result obtained by Ahmed (2004).

The coefficient of education is insignificant for groundnut. A negatively significant parameter of education means that technical efficiency decreases with the increase in education of farm operators. One of the reasons may be that the educated farmers were found to have alternative income sources. The coefficient of off-farm income has a positive sign and insignificant for groundnut. Similar result obtained by Ahmed (2004).

The coefficient of farm income has a positive sign and high significantly difference from zero at 10, 5, and 1 percent for groundnut. The reason is that the majority of income is directed toward crops production in NHAPC similar results obtained by Al-Feel and Al-Basheer (2012). The coefficient of irrigation number has a positive sign and high significantly difference from zero at 10, 5, and 1 percent for groundnut. That means irrigation is one of the main determinants of crops production in NHAPC. This result agree with findings of Ahmed (2004).

The coefficient of weeding number has a positive sign and significantly differenct from zero for groundnut. This result is in accordance with the recommendation from the New Halfa Research Station that weeds infestation adversely affect crops yield. NHAPC tenants face critical position due to coincide of weeding of cotton, groundnut and sorghum in the same period beside little time coupled with rainy season and lack of credit. Groundnut is labour intensive crop it requires 35 (man-days) per feddan. This result agree with findings of Moez (2008).

The coefficient of hired labour is a positive sign and significantly difference from zero for groundnut. Labour is required to carry out crop activities timely, particularly weeding and harvesting. That means labour is one of the main determinants of groundnut production in NHAPC. This result agree with findings of Ahmed (2004). The coefficient of family size for groundnut has a negative sign and insignificant.

Table 4 showed ML (Maximum likelihood) estimates of groundnut stochastic inefficiency, the estimated coefficients associated with explanatory variable in the model for inefficiency effects for NHAPC. Most of the estimated coefficients of the stochastic frontier model for groundnut have the expected sign.

The experience of tenant has a positive sign and has no significant effect upon the inefficiency model for groundnut crop. Extension contacts has significantly negative effect upon the inefficiency effects for groundnut. This means that, tenants with extension contact are more technically efficient than tenants with no extension contacts or we can say the technically inefficiency effect decreases with the increase the extension with tenants. Credit has significantly negative effect upon the inefficiency effects for groundnut. This means that, tenants who are not constrained by credit are more technically efficient than those who were constrained by credit. Field inspectors visit and schooling years have a positive sign and insignificant for groundnut this result is similar to Essilfie *et al.* (2011) and Rahman *et al.* (2012). We concluded that visits by field inspectors and schooling years are found to have no effect upon the inefficiency of groundnut. Animal ownership has a negative sign and insignificant for groundnut.

**Fig-1.** Technical efficiency score of producing groundnut in NHAPC, 2006 - 2007

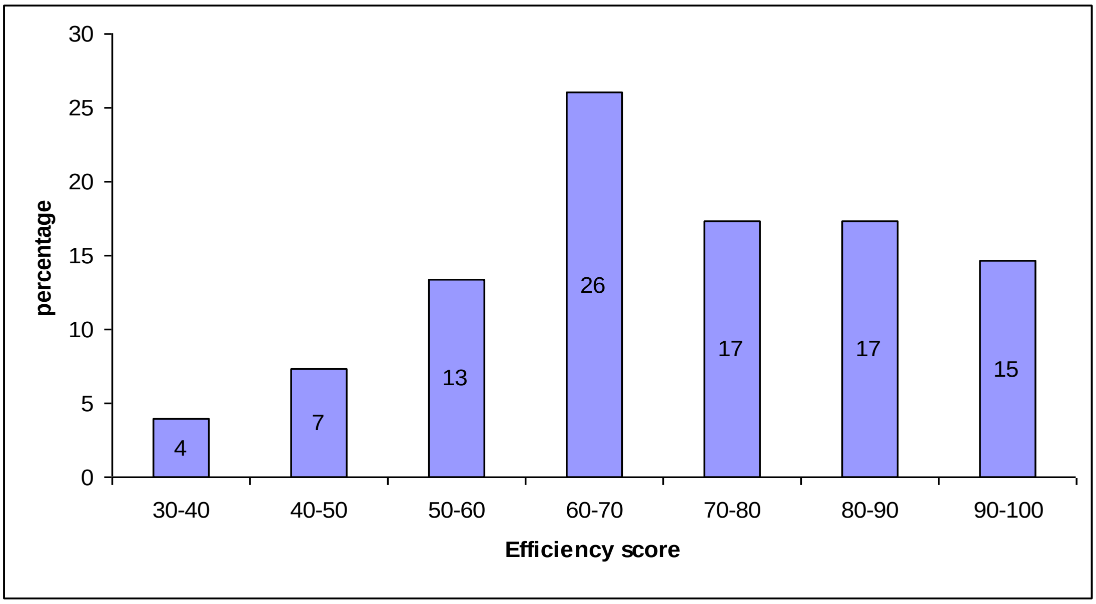


**Table-1.** Summary statistics of technical efficiency estimate of groundnut production, NHAPC, 2006 - 2007.

| Statistic | Efficiency score |
|---|---|
| Mean | 0.70 |
| Minimum | 0.35 |
| Maximum | 0.98 |

**Table-2.** Test of hypothesis for the parameters of groundnut production stochastic frontier function.

| Groundnut Production Model | | Decision |
|---|---|---|
| $H_0$: $\gamma = \mu = 0$ | 19.137 * | $H_0$: Rejected |
| LR $H_{0:}$ No technical inefficiency | 36.48 * | $H_0$: Rejected |

* Asterisk on the value of the parameters indicates significance at 5% level of significance

**Table-3.** Maximum-likelihood estimates of the stochastic frontier production function model for groundnut production.

| Parameters | Variable | Coefficient | Standard-error | T-ratio |
|---|---|---|---|---|
| $\beta_0$ | Constant | 0.709 | 0.527 | 1.343* |
| $_1\beta$ | Family size | -0.048 | 0.044 | -1.073 |
| $\beta_2$ | Tenancy location | -0.082 | 0.032 | -2.543** |
| $\beta_3$ | Irrigation | 0.498 | 0.199 | 2.508** |
| $_4\beta$ | Weeding | 0.206 | 0.137 | 1.508* |
| $\beta_5$ | Hired abour | 0.21 | 0.079 | 2.643** |
| $\beta_6$ | Off-farm income | 0.032 | 0.051 | 0.622 |
| $\beta_7$ | Education | -0.009 | 0.031 | -0.289 |
| $\beta_8$ | Farm income | 0.09 | 0.03 | 2.998*** |
| $\sigma_s^2$ | $\sigma_s^2 = \sigma_v^2 + \sigma^2$ | 0.067 | 0.068 | 4.431*** |
| $\gamma$ | $\gamma = \sigma^2 / \sigma_s^2$ | 0.96 | 0.05 | 19.137*** |
| Mean Efficiency | | | 0.7 | |
| Log likelihood function | | | 25.191 | |

*****, **** and ***** asterisks on the value of the parameters indicate significance at 1,5, and 10 percent level of significance respectively.

**Table-4.** Coefficients of inefficiency model

| Parameters | Variable | Coefficient | Standard-error | T-ratio |
|---|---|---|---|---|
| $\delta_0$ | Constant | 0.404 | 0.184 | 2.192** |
| $\delta_1$ | Experiences | 0.001 | 0.003 | 0.44 |
| $\delta_2$ | Extension | -0.2 | 0.088 | -2.279** |
| $\delta_3$ | Credit | -0.141 | 0.072 | -1.963** |
| $\delta_4$ | Inspectors visits | 0.037 | 0.035 | 1.084 |
| $\delta_5$ | Schooling years | 0.01 | 0.01 | 1.003 |
| $\delta_6$ | Animal ownership | -0.027 | 0.068 | -0.39 |

** Asterisks on the value of the parameters indicate it's significant at 5 percent level of significance respectively.

# 4. Conclusion

This work is Evaluation of Technical Efficiency for Groundnut (*Araches hypogaea* L.) Production: A Case Study of New Halfa Agricultural Corporation. Using a Cobb-Douglas in its stochastic frontier production function form. The study was based on primary data by using a structured questionnaire using Stratified random sampling techniques from 150 respondents, direct personal interviewing was used to fill the questionnaire. Differences in technology and efficiency of production process have prominent impact on agricultural productivity. Tenants in NHAPC were found to be technically efficient; therefore there is a scope for increasing groundnut production by 30% with present technology. Thus, most groundnut output discrepancy caused by differences in tenant's level of technical efficiency as opposite to the conventional random variability. The irrigation number, tenancy location, weeding, labor and farm income for producing groundnut were found to have greatest effect on improving technical efficiency. To improve groundnut production technical efficiency, the study recommended usage of herbicides, introduction of high yielding varieties, cleaning and maintenance of irrigation canals.

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