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Abstract—The study appraised the productivity gains of the World Bank Assisted Fadama II Project in the Nigerian Federal Capital Territory. The respondents made up of 980 and 870 Beneficiaries and Non-Beneficiaries respectively were drawn adopting multi-stage stratified random sampling technique. Stochastic Production Function Model was used to estimate the elasticities of production and the technical efficiencies of the two groups. The estimated Stochastic Production Function discriminated between the two groups on the basis of the factors (improved seeds and fertilizers) which the project assisted the participants to acquire. Elasticities of production for both the Beneficiaries and Non-Beneficiaries were 0.9 and 1.06 respectively. The mean efficiency for Beneficiaries and Non-Beneficiaries were 0.79 and 0.73 respectively with a significant mean difference among the groups. Given the productivity differential between the groups it is recommended that Fadama II Project which has tackled the Nigerian rural agricultural productivity problem be universally adopted throughout the Nigerian agriculture sector.

Index Terms—Fadama II, productivity and technical efficiency

I. INTRODUCTION

Nigeria has had long episode of productivity problems particularly in the agricultural sector. This has translated into poor mean yields (tonnes/hectare) of her six staple crops sorghum (1.01), millet (1.00), maize (1.20), rice paddy (1.60), yam (9.37) and cassava (10.27). Agriculture in Nigeria has therefore remained underdeveloped with Nigeria depending on the world market for wheat, rice, sugar and fish [1]. For example in 2010 Nigeria spent N635b ($4.23b) and N356b ($2.4b) on wheat and rice respectively.


An appraisal of the catalogues of agricultural programmes identified Nigeria as a country in a hurry to develop the agricultural sector, although with high level of policy instability. The programmes were often conflicting and duplicated in both aims and objectives. Most, if not all, adopted a “top-down” approach in both the planning and execution hence they could not make an appreciable impact on the Nigerian agricultural productivity front [2]. The net gain therefore was a drop in food self-sufficiency ratio from 98% in early 1960s to less than 54% in 1986. About 18% of the population (14.4 million) was estimated to be critically food insecure in 1990 and increased to 36% (32.7 million) in 1992.

The National Fadama Development Project was established in 1993 as one of the World Bank’s Assisted Programmes which deviated in both philosophy, design and execution from the previous projects and programmes. It enjoyed a tripartite support of both the World Bank, the Federal Government and the State Governments.

Figure 1. Map of Nigeria showing river lakes, estuaries, creeks and lagoons
The Fadama concept is an age-old tradition in Hausa land, a prominent tribe in Sub-Sahara West Africa, where land that floods on seasonal basis allows for the growth of a variety of crops under small-scale irrigation farming system [3]. These lands are of high fertility level given the rich alluvial soil in abundance within the catchment areas. The Fadama generally occurs in lowlands of the three land forms: the Coastal plains, Inland depression (inland basins and inland valleys) and Alluvial plains (river flood plains) with Coastal plains being the most extensive in Nigeria [4]. Most of this land is found in the Northern States of Nigeria for example, 3.144 million hectares of this land is distributed in Northern and Central geopolitical zones of Nigeria (Fig. 1).

Guthrie [5] identified the soils of Fadama as of a great potential for sustainable food production because of their inherent fertility status and flat landscape with minimal soil erosion potential. Most of the top soils washed down from hinterlands into the coastal plains and those washed down from the little uplands into the inland basins and valleys fertilize the Fadama lands. Abdullahi and Phillip [6] indicated the grains of Fadama lands to include full utilization of productive resources through double or continuous utilization of the available land and other resources particularly the farm family labour which lies idle outside the rain-fed agriculture. The huge gains of enterprise complementarily and supplementarily are part of the derivatives of Fadama land agriculture [7]. Other gains include stability of output through a more stable production trend, additional income sources and low incidence of plant disease. In the Fadama catchment plains, the water tables are high, thus with little irrigation efforts, the crop yields are maximized with the available abundant sunshine which enhances rapid evapotranspiration.

The Nigerian food security problems borne on poor agricultural technology, low flows of time, place and form utilities therefore find solution in the Fadama II programme.

At its fully developed stage (Fadama II), the project activities revolved around the Fadama User Groups (FUGs) and Fadama Community Associations (FCAs) which are consistent with features of a Community-Driven Development (CDD) project.

In its design, an FUG comprises Fadama users with a common economic interest and is therefore a type of economic interest group. FCAs are the associations of FUGs (about 15 of them) operating in a given area. Each FCA designs and oversees the implementation of a Local Development Plan which is the blue print of the Fadama II, the development project in that FCA. The major productive sectors that Fadama II supports include crops, livestock, agro forestry, fishing and fish farming [1], [7], [8]. Fadama II Project fits neatly into the Nigerian rural tradition and Institution. In all likelihood, it has great potential to enhance rural agricultural productivity.

II. OBJECTIVES OF THE STUDY

The focus of the study is to analyse the crop productivity gains of Fadama II in the Federal Capital Territory of Nigeria. The specific objectives are to:

- Estimate the elasticities of the farm inputs for both the Beneficiaries and Non-Beneficiaries of Fadama II crop enterprises;
- Estimate the returns to scale for the Beneficiaries and Non-Beneficiaries of Fadama II crop enterprises; and
- Estimate and compare the mean efficiencies of the Beneficiaries and Non-Beneficiaries of Fadama II crop enterprises.

Hypothesis: There is no significant difference in the mean efficiency of the Beneficiaries and Non-Beneficiaries of Fadama II crop enterprises.

III. METHODOLOGY

A. The Study Area

This study was conducted in Federal Capital Territory (FCT), Abuja, Nigeria. FCT comprises six Area Councils which were delineated into ten Fadama Development Areas (FDAs) for the purpose of Fadama II Project. The territory is located within the savanna zone, it occupies an area of 800,000 hectares. The territory has an estimated population figure of 1,405,201 inhabitants. The FCT has a total of 93,092 farming households, 446,506 farming population and about 50,000 Fadama farming families. The FCT has 87 Fadama Community Associations (FCAs) and 708 Fadama User Groups (FUGs) that participated in Fadama II. It is situated in the heart of the nation lying within latitudes 7°25’ and 9°20’ North and longitudes 6°45’ and 7°30” East. The farm families are involved in small scale farming and upstream production of crops (yam, rice, maize, sorghum, millet, etc.), livestock, fisheries, agro forestry etc. and downstream activities of processing and marketing.

B. Population, Sampling Technique and Sample Size

The population for the study comprised Beneficiaries and Non-Beneficiaries within Fadama Development Areas (FDAs) in the FCT. A multistage stratified random sampling technique was adopted as the sampling technique. In the first stage, two FDAs (Abuja Municipal Area Council [AMAC and Gwagwalada]) were purposively selected based on the large number of Fadama User Groups (FUGs) in the FDAs. In the second stage, the sampling frame of Fadama Community Associations (FCAs) were prepared for each FDAs and 10% sampling proportion was applied in the selection of FCAs giving 5 FCAs each from the FDAs.

Sampling frames of Fadama User Groups (FUGs) were prepared per FCA selected and a sampling proportion of 50% was applied to select FUGs per FCAs. Finally, 10 respondent farmer households were selected per FUGs using lottery method. A total of 1,000 farmer household Fadama Beneficiaries were selected for the study. Similarly stratified random sampling technique was also applied to the various strata – Agricultural zones, Area Councils, Villages and households for the selection of Non-Beneficiaries households. A total of 1,000 Non-Beneficiaries were selected. Respondents with valid responses for analysis were 980 Beneficiaries and 870 Non-Beneficiaries.

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C. Method of Data Analysis and Empirical Specification

The data for this study were analyzed using both descriptive statistics and inferential statistics. The descriptive statistics like percentage and frequency distribution was employed to describe the distributions of the classes of inefficiencies among the Beneficiaries and Non-Beneficiaries of Fadama II Project. Cobb-Douglas Stochastic Frontier Analysis was used to analyze the technical efficiency of crop farmers.

The Stochastic Frontier Production function was used to capture and compare the production frontier and technical efficiency in production process of the Fadama II project Beneficiary and Non-Beneficiary farmers. It has been conveniently applied in similar studies where productivity and efficiency are measured and analysed [9]. The parameters of the models were obtained by the use of Maximum Likelihood estimation method using the computer software Frontier version 4.1 [10]. The model is specified as:

\[ Y_i = F(X_i; \beta) \exp(V_i - U_i) \]

Specifically, the production technology (Technical efficiency) of Fadama II Beneficiary and Non-Beneficiary farmers was estimated using the Cobb-Douglas functional form of the stochastic Frontier Production function model which is defined as follows:

\[ \ln(Y_i) = \ln(\alpha) + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + (V_i - U_i) \]

where \( Y_i \) = Farm output \( i^{th} \) farmer (in kg); \( X_i \) = Vector of actual farm input quantities used by the \( i \)th farmer (\( X_i = X_1 - X_5 \)); \( X_1 \) = Farm size (in hectares); \( X_2 \) = Planting materials (in kg); \( X_3 \) = Fertilizer (Kg); \( X_4 \) = Chemical (l); \( X_5 \) = labour (in man-day); \( \beta \) = vector of production function parameters to be estimated; a, priori expectation is positive.

\( V_i - U_i \) = is composite error term
\( V_i \) = random variability in the production that cannot be influenced by the farmers, \( N \sim (0, \sigma^2) \).
\( U_i \) = is a non-negative random variable associated with technical inefficiency in production, \( N \sim (\mu, \sigma^2) \).

\[ \mu = \sigma_0 + \sigma_1 Z_{1i} + \sigma_2 Z_{2i} + \sigma_3 Z_{3i} + \sigma_4 Z_{4i} \]

where:
\( Z_1 \) = Age of the farmer (in years)
\( Z_2 \) = Experience in farming (in years)
\( Z_3 \) = Household size (number in household)
\( Z_4 \) = Education (level of education in years)
\( \sigma_0 - \sigma_4 \) = unknown parameters to be estimated (scalar)

IV. RESULTS AND DISCUSSION

A. Effect of Input Use on Output among the Beneficiaries and Non-Beneficiaries of Fadama II Project

Table I summarizes the estimates from Stochastic Production Function for Beneficiaries and Non-Beneficiaries of Fadama II Project. The result indicated that farm size, labour cost, seed cost, and fertilizer cost were the inputs that significantly affected output of the Beneficiaries of Fadama II Project. For the Non-Beneficiaries only farm size significantly affected output. Farm size, seed cost and fertilizer cost positively and significantly affected the output of Beneficiaries of Fadama II Project at 5% level of probability in the least. This implied that increases in these inputs by one percent would also increase the output by the percentages of their respective coefficients. This is in agreement with the research finding of Umeh and Ataboh [11] who found that farm size and fertilizer positively and significantly affected the output of rice farmers in Kogi State. Labour use negatively and significantly affected the output implying that increase in quantity of labour use would reduce the output by the value of its coefficient. This implies misuse of labour by the Beneficiaries of Fadama II project.

### Table I. Maximum Likelihood Estimate of Production Function for Beneficiaries and Non-Beneficiaries of Fadama II Project

<table>
<thead>
<tr>
<th>Variables</th>
<th>Beneficiaries</th>
<th>Non-Beneficiaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>19.50 (9.27)*</td>
<td>25.32 (25.48)</td>
</tr>
<tr>
<td>Farm size</td>
<td>1.53 (5.48)*</td>
<td>2.29 (3.69)*</td>
</tr>
<tr>
<td>Labour cost</td>
<td>-0.96 (-1.75)*</td>
<td>-1.21 (-1.43)</td>
</tr>
<tr>
<td>Seed cost</td>
<td>0.15 (1.87)*</td>
<td>0.06 (0.09)</td>
</tr>
<tr>
<td>Fertilizer cost</td>
<td>0.31 (3.26)*</td>
<td>0.18 (0.26)</td>
</tr>
<tr>
<td>Pesticide cost</td>
<td>-0.23 (-0.56)</td>
<td>-0.30 (-0.30)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.10 (1.14)</td>
<td>0.04 (0.07)</td>
</tr>
</tbody>
</table>

*Significant at 1% level; **Significant at 5% level. Values in parenthesis represent t-ratios.

Seed and fertilizer which positively and significantly influenced the output of the Beneficiaries did not significantly influence the output of the Non-Beneficiaries. These were the inputs which Fadama II Project assisted the Beneficiaries to acquire for use on their farms.

The elasticity of production for the Beneficiaries and Non-Beneficiaries of Fadama II Project were 0.90 and 1.06 respectively, thus the Beneficiaries operated in the region of decreasing returns to scale and the Non-Beneficiaries operated in the first phase of production function, a region of limited input use. The Non-Beneficiaries were not assisted in their production through the supplies of inputs like fertilizers and seeds, they could therefore not push production into an optimum phase of production (region II).

In contrast, the Beneficiaries were assisted with the inputs consequent upon their membership of Fadama User Group and also through the co-ordination of Fadama Community Association, the Apex group. They therefore had enough quantum of input to operate beyond the region of increasing returns to scale to the region of diminishing returns to scale.

Both groups (Beneficiaries and Non-Beneficiaries) had their output positively and significantly influenced by farm size. The farms under Fadama II Project are the flood plains and each farm family participating in the dry season production has access to the wetland. In order words this may not necessarily be a discriminating factor. The key distinguishing factors for Fadama II Project are
seed, fertilizer and pesticides. This is because the boosting of productivity by Fadama II Project operates on these factors which could be largely attracted through Fadama II. In this situation therefore, the Beneficiaries had their output boosted through the use of these inputs which they obtained largely from Fadama II Project.

B. Determinants of Technical Inefficiency of Beneficiaries and Non-Beneficiaries of Fadama II Project

The result of estimated parameters of the inefficiency effects of Beneficiaries and Non-Beneficiaries of Fadama II Project are laid in Table II. The estimated sigma square ($\sigma^2$) is significant at 1% level for the Beneficiaries group, but not for the Non-Beneficiaries indicating goodness of fit and, correctness of the specified distribution assumption of the composite error terms. The estimated gamma ($\gamma$) is significant at 1% in both groups implying that variability in the output of both groups is due to technical inefficiency.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>Non-beneficiaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Z_a)</td>
<td>0.36 (0.56)</td>
<td>-0.14 (-0.20)</td>
</tr>
<tr>
<td>Experience (Z_e)</td>
<td>0.29 (2.04)**</td>
<td>0.25 (0.62)</td>
</tr>
<tr>
<td>Household Size</td>
<td>-0.47 (-2.67)**</td>
<td>-0.02 (-0.04)</td>
</tr>
<tr>
<td>Education (Z_e)</td>
<td>0.33 (2.80)**</td>
<td>(0.1) (0.66)</td>
</tr>
<tr>
<td>Variance</td>
<td>0.05 (3.48)*</td>
<td>0.01 (1.04)</td>
</tr>
<tr>
<td>Gamma (Y)</td>
<td>0.84 (11.31)*</td>
<td>0.99 (38.04)*</td>
</tr>
<tr>
<td>Likelihood</td>
<td>21.81</td>
<td>13.85</td>
</tr>
</tbody>
</table>

*Significant at 1% level; **Significant at 5% level values in parenthesis represent t-ratio.

The estimated coefficients of technical inefficiency effects model indicated that for the Beneficiaries group, farming experience, household size and education significantly influenced technical inefficiency. None of these variables had any significant influence on the technical inefficiency of the Non-Beneficiaries. Age had no significant influence on technical inefficiency of both Beneficiaries and Non-Beneficiaries groups. For the factors that have significant effects, they also have varying implications on the technical inefficiency effects. For farming experience with positive coefficient, as the farming experience increases, the technical inefficiency increases too. The implication being that as farming experience increases, the farmer becomes immune to changes, he/she becomes dogmatic and keeps to the old ways of doing things shunning new technologies thus increasing the inefficiency effects. As for the household size which has a negative coefficient implying that as household size increases technical inefficiency decreases. This is contrary to the expected since increases in the household size brings its distraction from the farming activities as the head of household fends for the needs of each of the members of the household and therefore spreads his/her time and efforts too thinly across the various responsibilities. However, it could mean that the enlarged household size could have members who have knowledge and orientation on agricultural technologies which are infused into the farming system and therefore reduce the technical inefficiency effects.

The education factor has a positive coefficient implying that as the level of education increases the technical inefficiency increases too. This is contrary to the expected since with increase in the level of education the farmer is better placed to read pamphlets and user manual which come with the material technologies and therefore apply them better than one with poor education. This leads to reduction in the technical inefficiency. However, the contrary result obtained would be attributed to the poor education being received in most rural schools in Nigeria as a result of incessant strikes and lock-outs due to friction between the teachers and the government. This produces “half backed products”, graduates of primary, secondary and even tertiary institution who may not perform. This, in the final analysis leads to increase in inefficiency as the educational level rises.

C. Technical Efficiency Distribution among Beneficiaries and Non-Beneficiaries of Fadama II Project

Table III presents the distribution of Technical Efficiency estimates of crop farmers for Beneficiaries and Non-Beneficiaries of Fadama II Project. The results revealed that technical efficiencies of crop farmers (Beneficiaries) ranged between 0.53 and 0.98 with a mean of 0.79 while that of Non-Beneficiaries ranged between 0.45 and 0.99 with a mean of 0.73.

The results further revealed that over 90% of the Beneficiaries had technical efficiency exceeding 60% while about 86% of the Non-Beneficiaries had technical efficiency exceeding 60%. This implies that majority of the respondents, Beneficiaries and Non-Beneficiaries operated closer to their production frontiers. However, based on the respective mean technical efficiencies, there is scope for increasing crop production efficiency by about 21% and 27% by the Beneficiaries and Non-Beneficiaries respectively.

<table>
<thead>
<tr>
<th>Range</th>
<th>Beneficiaries Frequency</th>
<th>Percentage</th>
<th>Non-Beneficiaries Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.31 – 0.60</td>
<td>94</td>
<td>9.59</td>
<td>120</td>
<td>13.79</td>
</tr>
<tr>
<td>0.61 – 0.90</td>
<td>566</td>
<td>57.76</td>
<td>680</td>
<td>78.16</td>
</tr>
<tr>
<td>0.91 – 1.00</td>
<td>320</td>
<td>32.65</td>
<td>70</td>
<td>8.06</td>
</tr>
<tr>
<td>TOTAL</td>
<td>980</td>
<td>100.00</td>
<td>870</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Minimum efficiency 0.53 0.45
Maximum efficiency 0.98 0.99
Mean efficiency 0.79 0.73
Table IV shows the test of mean difference of technical efficiency of Beneficiaries and Non-Beneficiaries of Fadama II Project.

The technical efficiency estimate for the Beneficiaries was significantly higher than that of Non-Beneficiaries as shown in the mean test difference. This result empirically shows that the Beneficiaries have a higher productivity status and thus more efficient than the Non-Beneficiaries. It therefore buttresses the results of returns to scale observed in the input-output analysis where the Beneficiaries operated in the region of diminishing returns while the Non-Beneficiaries operated in the region of increasing returns to scale.

V. SUMMARY AND CONCLUSION

A. Summary

Nigeria’s long episode of poor productivity particularly in the agricultural sector has translated into poor mean yields of her six staple crops – sorghum, millet, maize, rice paddy, yam and cassava. Nigeria has, therefore, depended on the world market for the supplies of food materials which she has huge factor endowment for their production. In the final analysis the net gain therefore was a drop in food self-sufficiency ratio from 98% in early 1960s to less than 54% in 1986 and also an increasing population estimated to be critically food insecure.

Nigeria has never been short of programmes designed to tackle her food problems. However, none of these programmes has ever been executed to its full project complete status without being replaced with some other programme/projects as a result of policy instability. This study appraises the productivity gains of the World Bank Assisted Fadama II Project which could be adjudged to have had some major productivity gains in the Nigerian agricultural sector. The philosophy of this initiative is consistent with features of a Community-Driven Development (CDD) project. Its basic building blocks are Fadama User Groups (FUGs) and Fadama Community Associations (FCAs). Through a stratified random sampling design 980 Beneficiaries and 870 Non-Beneficiaries of Fadama II Project were sampled for the study. Descriptive and Inferential statistics were adopted for the analysis.

The estimated Stochastic Production Function discriminated between the Beneficiaries and Non-Beneficiaries of Fadama II Project on the basis of the factors (improved seeds and fertilizers) which the project assisted the participants to acquire. The elasticities of production for both the Beneficiaries and Non-Beneficiaries of Fadama II Project were estimated as 0.9 and 1.06 respectively. The mean efficiency for Beneficiaries and Non-Beneficiaries are 0.79 and 0.73 respectively. Based on these values the two groups operated closer to their production frontiers, however there is scope for increasing crop production efficiency by about 21% and 27% for Beneficiaries and Non-Beneficiaries respectively. The technical efficiency estimate for the Beneficiaries was higher than that of the Non-Beneficiaries as shown in the test of mean difference.

B. Conclusion

The Fadama II Project philosophical foundation which is consistent with features of a Community-Driven Development (CDD) has led to solving the productivity problems in the Nigerian agricultural sector. Its building blocks which include Fadama User Groups (FUGs) and Fadama Community Associations (FCAs) are key agricultural productivity enhancement elements. Given the productivity differential between the Beneficiaries and Non-Beneficiaries in favour of the former, it is recommended that Fadama II Project be universally implemented throughout the Nigerian agricultural sector.

REFERENCES

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