**International Journal of Social Sciences and Humanities**
ISSN: 2360-9877. Volume 11, Issue 1, (July, 2024) pages 172 – 186
DOI: 27265774111101123
arcnjournals@gmail.com
https://arcnjournals.org

# Empirical Panacea to the Challenges of Rice Farming in Northern Nigeria

**Ali Mustapha[1] and Yunusa Mohammed Kaigama[2]**
[1]Department of General Studies, Federal Polytechnic Damaturu, Yobe State
[2]Department of Banking and Finance, Federal Polytechnic Damaturu, Yobe State

***Abstract***: *This study attempts to provide a solution to the persistent issue of poor harvest and low yield among rice farmers in northern Nigeria. Analysis reveals that adopting new and improved techniques and abandoning traditional practices are the way forward. Government policies towards providing subsidized farm inputs such as tools, tractors and seeds are integral to the success of rice farming in Nigeria.*

***Keywords:*** *Rice Farming Employment Generation, Growth.*

## INTRODUCTION

Rice farming is one of the most significant agricultural activities in Nigeria, a country known for its rich soil and favourable climate. Nigerian rice cultivation is a vital source of livelihood for millions of farmers across the country, providing food security and income generation.

Cultivating rice in Nigeria involves various practices ranging from planting to processing. Despite its importance, several challenges still hinder the growth of Nigeria's rice agriculture.

In this research, we will explore the intricacies of rice farming in northern Yobe state, including the cultivation practices, challenges, processing techniques, and the future prospects of the industry.

### Rice Cultivation Practices in Nigeria

**Rice farming in Nigeria** involves various planting techniques dependent on the farmers' preference, access to technology and soil condition. In Nigeria, the most commonly used planting techniques for rice cultivation are direct wet seeding and transplanting rice seedlings. Transplanting allows for better weed control and efficient use of land. However, it requires more labour, irrigation, and a longer growing period. Direct seeding is faster, but it results in lower yields due to competition from weeds, water stress, and other environmental factors.

One significant challenge of **rice farming in Nigeria** is pests and diseases, which can significantly impact yields. The most common pests include stem borers, rice bugs, and rats, while diseases such as blast, sheath blight, and bacterial leaf blight pose a significant risk to the crops. Additionally, farmers also face challenges such as lack of access to finance, inadequate infrastructure, and climate change.

The most commonly grown rice varieties in Nigeria are upland and lowland rice. Lowland rice is grown in flooded conditions, while upland rice is grown in non-flooded areas. Both varieties have different soil and water requirements and can be farmed using different techniques.

**Rice Planting Techniques in Nigeria**

- **Direct Wet Seeding**: Seeds are planted directly into the wet soil without being soaked or pre-germinated. This method is faster, but it needs more water and often results in lower yields due to weed competition.
- **Transplanting:** Seedlings are grown in nurseries and then transplanted to the field, providing better weed control.

**Rice Harvest in Nigeria**

The **rice harvest in Nigeria** typically occurs from October to December, following the rainy season. Farmers use a variety of techniques to harvest rice, including manual labour and mechanized equipment, depending on the scale of their operations.

The average rice yield per hectare in Nigeria is 2.5 to 4 tons, although this can vary depending on factors such as the rice variety, soil quality, and weather conditions. Some farmers are able to achieve higher yields through the use of fertilizers, pesticides, and improved seed varieties.

**Tools and Techniques**

During the **rice harvest in Nigeria**, farmers typically use knives, sickles, or mechanical combine harvesters to cut the rice stalks. The rice is then threshed to separate the grain from the straw.

Nigeria is home to a thriving rice farming industry with diverse processing techniques employed to convert harvested paddy into finished rice. The process begins with threshing the rice to separate the grain from the straw. This is followed by milling which removes the husk and bran layers, leaving only the white endosperm.

The next step is polishing, where the white rice undergoes a polishing process to remove any remaining bran layer and improve the rice's appearance. After polishing, the rice is sorted into different grades based on size, shape, and color. Broken rice, which is a by-product of the milling process, is also separated and processed differently.

The **rice supply chain in Nigeria** plays a crucial role in the processing of rice as it connects the farmers with rice millers and processors. The supply chain also ensures proper storage and transportation of the rice to the market.

Further processing techniques and innovations in mechanization and irrigation systems are being explored to improve the efficiency of rice processing in Nigeria. These methods focus on improving the quality of the final product while minimizing waste and reducing processing times.

- **Threshing**: separating the grain from the straw.
- **Milling:** removing the husk and bran layers from the rice.

- **Polishing:** removing any remaining bran layer and improving the appearance of the rice.
- **Sorting**: separating the rice into different grades based on size, shape, and colour.

The processing techniques employed in Nigerian rice farming are crucial to the industry's success. With the government's support and innovative practices being developed, rice processing is set to become more efficient and profitable in Nigeria.

**Rice Farming Innovations in Nigeria**

As the demand for rice increases in Nigeria, so does the need for innovative farming practices to increase productivity and efficiency. The adoption of modern technologies and techniques has been crucial in improving rice farming in Nigeria.

**Mechanization**

Mechanization has played a significant role in transforming rice farming in Nigeria. The use of tractors, harvesters, and other machinery has made farming easier, faster, and more efficient. Mechanization has also reduced labour costs and increased yields. Moreover, mechanized farming has aided in achieving sustainable farming practices by reducing the negative impact on the environment.

**Irrigation Systems**

Irrigation systems are critical in rice farming, especially during the dry season. Droughts and irregular rainfall patterns have made irrigation necessary for rice farming in Nigeria. The government and private investors have invested in building dams and irrigation systems to improve access to water for rice farming. Modern irrigation systems like drip irrigation have also helped to save water and maximize its usage.

**Improved Seed Varieties**

The use of improved seed varieties has increased the yield and quality of rice produced in Nigeria. These seeds are disease-resistant and have a higher tolerance for various weather conditions. The government and private sector have invested in research and development to produce high-quality hybrid seeds suitable for local conditions.

**Processing Techniques**

Improved processing techniques have also played a significant role in boosting Nigerian rice farming. The adoption of modern milling machines and processing plants has improved the quality of rice produced in Nigeria. Efficient processing also reduces the amount of waste produced and increases profitability for farmers.

**Table 1: Comparison between Nigeria and the rest of West Africa**

| Indicator | Mean (1961–75) tons | Mean (1976–82) tons | Mean (1983–85) tons | Mean (1995–2000) tons |
|---|---|---|---|---|
| Nigeria | | | | |
| Production | 332,800 | 806,222 | 230,6794 | 318,9833 |
| Import | 2,036 | 420,756 | 334,974 | 525,307 |
| Self-reliance ratio | 99% | 54% | 77% | 79% |
| Total consumption | 178,199 | 833,640 | 1,599,609 | 2,248,113 |
| Per capita consumption | 3.0 | 12.0 | 18 | 22 |
| West Africa without Nigeria Production | 1,779,376 | 2,344,073 | 2,822,635 | 4,041,384 |
| Import | 416,183 | 894,073 | 1,760,884 | 2,107,146 |
| Self-relianceratio | 65% | 56% | 42% | 50% |
| Total consumption | 1,178,753 | 1,950,821 | 2,973,885 | 3,985,721 |
| Per capita consumption | 21.0 | 27.0 | 30.0 | 34 |

Source: Computed from FAO – AGROSTAT (2000)

### *Rice production trends in Nigeria*

*Rice farming started in Nigeria in 1500 BC with the low-yielding indigenous red grain species Oryza glaberrima Stued that was widely grown in the Niger Delta area (Hardcastle, 1959). The high-yielding white grain, O. sativa L., was introduced about 1890 and by 1960 accounted for more than 60% of the rice grown in the country. Today, rice is cultivated in virtually all the agro-ecological zones in Nigeria, but on a relatively small scale. In 2000, out of about 25 million hectares of land cultivated to various food crops, only about 6.7% was under rice (PCU, 2001). The trend in production shows that paddy rice first experienced a boom in the 1965–1970 period, when average output stood at 321,000 tons (Table 2). During this period, average area cultivated to rice stood at 234,000 hectares while average national yield was 1.36 tons/ha. Another significant improvement in rice production in Nigeria was recorded in 1986–1990, when output increased to over 2 million tons while average area cultivated and yield rose to 1,069,200 hectares and 2,096 tons/ha, respectively. Throughout the 1980s, rice output and* *yield increased. But in the 1991–1995 period, while rice output increased yield of rice declined, which implies that the increased output was a result of extensive land cultivation.*

There was also great disparity among the states of the federation in rice production in terms of both output and yield. In 2000, Kaduna State was the largest producer of rice, accounting for about 22% of the country's rice output. This was followed by Niger State (16%), Benue State (10%) and Taraba State (7%) (FMARD, 2001). Great variations also exist in terms of yield. The average national rice yield during the dry season (3.05 tons/ha) was higher than that of the wet season (1.85 ton/ha).

**Table 2: Rice production trends in Nigeria (1961–2000)**

| **Period** | **Average area cultivated (hectare)** | **Average output (tons)** | **Average yield (tons/ha)** |
|---|---|---|---|
| 1961-1965 | 179,200 | 207,200 | 1.147 |
| 1966-1970 | 234,000 | 321,000 | 1.360 |
| 1971-1975 | 288,800 | 470,200 | 1.670 |
| 1976-1980 | 332,000 | 596,200 | 1.710 |
| 1981-1985 | 630,000 | 1,300,200 | 2.063 |
| 1986-1990 | 1,06,200 | 2,216,064 | 2.090 |
| 1991-1995 | 1,678,000 | 2,979,600 | 1.783 |
| 1996-2000 | 1,742,582 | 3,011,028 | 1.733 |

Source: PCU, FMARD, Nigeria (2002).

## LITERATURE REVIEW

Studies conducted either in Nigeria or elsewhere have identified several factors affecting the efficiency of resource use by crop farmers. Some of these studies are reviewed in this section. Ogunfowora *et al.* (1974), in examining resource productivity in traditional agriculture in Kwara State, Nigeria, estimated a Cobb–Douglas production.

function through a method of ordinary least square (OLS) and discovered that labour and seed inputs were inefficiently utilized. Farm size (scale of operation) and the level of technology were not taken into consideration, however, which made the result too generalized. Using the same Cobb–Douglas production function in Imo State (Oludimu 1987) examined the efficiency of resource use in various farm enterprises and concluded that the efficient use of resources took place only at the rational stage of production (i.e., at the decreasing but positive return to scale stage). Further examination of the independent variable, however, revealed a diminishing marginal return and decreasing return to scale on farm investment and over-utilization of resources. This study suffered the same drawback as the one mentioned earlier. Adesina and Djato (1997) used a normalized profit function to determine the relative efficiency of male and female rice farmers in Côte d'Ivoire. The result of the study showed that the relative degree of efficiency of women was similar to that of men.

Earlier, Lau and Yotopolous (1971) estimated an equation for the profit function in differences in economic efficiency between large and small farms in India and found that small farms attained a higher level of economic efficiency. Sahidu (1974) adopted the Lau–Yotopolous model to sample of Indian wheat farms and came out with a contrary conclusion – that large and small farms exhibited equal economic efficiency in both the technical and price senses. In Pakistan, Khan and Maki (1979) also adopted the Lau–Yotopoulos model to determine the effects of farm size on economic efficiency in two locations, Punjab and Sind. They found that large farms are more efficient than small farms by 18% in Punjab and 51% in Sind. Some studies have also adopted the stochastic frontier approach for efficiency analysis.

Kalirajan (1981b) used a Cobb–Douglas production function to estimate the economic efficiency of farmers growing high-yielding, irrigated rice in India. He compared the small and large farm groups and concluded that there was equal relative economic efficiency in the cultivation of IR20 in rabi season between the groups. Bagi (1982) estimated a stochastic frontier Cobb–Douglas production function to determine whether there were any significant differences in technical efficiencies of crop and mixed enterprise farms in West Tennessee in the USA. The variability of inefficiency effects was found to be highly significant and the mean technical efficiency of mixed enterprise farms was smaller than that of crop farms (0.76 and 0. 85, respectively). Bagi and Huang (1983) estimated a translog stochastic frontier production function using the same farm data as Bagi (1982). The Cobb–Douglas stochastic frontier model was found not to be an adequate representation of the data, given the specification of the translog model for both crop and mixed farms. The mean technical efficiencies of crop and mixed farms were estimated to be 0.73 and 0.67, respectively. Kalirajan and Flinn (1983) used the translog stochastic frontier production function in the analysis of data on 79 rice farmers in Philippines. The individual technical efficiencies ranged from 0.38 to 0.91. In Australia, Battese and Coelli (1988) applied a panel data model in the analysis of technical efficiency in dairy farms in New South Wales and Victoria over three years. The estimated technical efficiencies ranged between 0.55 to 0.93 for New South Wales farms and between 0.39 and 0.93 for Victoria farms. Battese and Tessema (1993) estimated stochastic frontier production functions with time-varying technical inefficiency for Indian farmers. While the results show that technical efficiencies varied widely, the hypothesis of time-invariant technical efficiency is not rejected in one of the three villages. Dawson et al. (1991) used a stochastic production frontier to measure farm-specific technical efficiency in rice farms of Central Luzon, Philippines, and found a narrow range of efficiency – 84–95% – across the 22 farms sampled. In this same study, a comparison was made with measures of technical efficiency using traditional covariance analysis. The results showed that the distributions of efficiencies obtained from both stochastic frontier and covariance analysis approaches are different. Potential gains in technical efficiency are small for the former but are relatively large for the latter, which means that those obtained from the stochastic frontier are preferred. Heshmati and Mulugata (1996) estimated the technical efficiency of Ugandan *matoke* producing farmers and found that the farmers face production technologies with decreasing return to scale. The mean technical efficiency was 65%, but there was no significant variation in technical efficiency with respect to farm size.

Seyoum et al. (1998) investigated the technical efficiency and productivity of maize producers in Ethiopia. The findings show that farmers who participate in a programme of technology demonstration are more technically efficient than farmers who do not. Townsend *et al.* (1998) used data envelopment analysis to investigate the relationships among farm size, return to scale and productivity among wine producers in South Africa. Their study found that most farmers operate under constant return to scale, with a weak inverse relationship between farm size and productivity.

Ajibefun and Abdulkadri (1999) estimated technical efficiency for food crop farmers under the National Directorate of Employment in Ondo State, Nigeria. The results of the analysis indicated wide variation in the level of technical efficiency, between 0.22 and 0.88. Mochebele and Winter-Nelson (2000) investigated the impact of labour migration on technical efficiency performance of farms in Lesotho. Using the stochastic frontier production, the study found that households that send migrant labour to South African mines are more efficient than households that do not, with mean technical efficiency of 0.36 and 0.24 respectively. Obwona (2000) estimated a trans log production function to determine technical efficiency differentials between small- and medium-scale tobacco farmers in Uganda using a stochastic frontier approach. The estimated efficiencies were explained by socioeconomic and demographic factors. The results showed that, credit accessibility extension services and farm assets contribute positively towards the improvement of efficiency. One major drawback of this study is the inability of the author to show in clear terms whether there is any differential in efficiency between the two groups of farmers. Most of the earlier studies cited concentrated on aggregate data and employed relatively simple statistical tools. More importantly, there were no efforts made to quantify the magnitude of the contribution of the various factors affecting productivity.

**Methodology**

Secondary data were used for this research. The stochastic frontier model used in this study is a variant of that of Khumbhakar and Heshmati (1995), Yao and Liu (1998), and Ogundele (2003). The model specified output (Y) as a function of inputs (X) and a disturbance term (μ):

$$Y_i = h(X_{ij}\ X_{ij} \ldots, X_{ij};\ A;\ e_i) \quad (1)$$

where $Y_i$ is output by farmer i, $X_{ij}$ is input *j* of *n* inputs, and *A* is a vector of parameters. The disturbance term consist of two components, $e_i = V_i - U_i$, where $V_i \sim N(0, s_v^2)$, and $U_i$, which is a one-sided error term. The two errors, $V_i$ and $U_i$, are assumed to be independently distributed. The term $V_i$ is symmetric, allows random variation of the production function across farms, and captures the effects of statistical noise, measurement error and exogenous shocks beyond the control of the producing unit. The one-sided term, $U_i$, represents technical inefficiency (TI) relative to the stochastic frontier. If $U_i = 0$, production lies on the stochastic frontier and production is technically efficient; if $U_i > 0$, production lies below the frontier and is inefficient. The error term $U_i$ is usually assumed to follow one of three possible distributions (Lee, 1983; Schmidt and Lin, 1984; Bauer, 1990): (a) half-normal, i.e., $|N(0, s_u^2)|$; (b) exponential $Exp(\mu_u, s_u^2)$; and (c) truncated normal at zero $N(\mu_u, s_u^2)$. Because the estimates of technical efficiency are similar for each distribution, half-normal and truncated normal could be used. Following Jondrow et al. (1982), technical inefficiency (TI) for each observation is calculated as the expected value of $U_i$ conditional on $e_i = V_i - U_i$:

**RESULTS**

The study found that technology plays a very significant role in determining the levels of technical efficiency of Nigerian rice farmers. However, where the producing unit did not comply strictly with recommendations, the results were not up to expectations. Apart from the technical characteristics of the production process and changes in relative input-output prices, other factors that were found to significantly influence the average level of efficiency and productivity of farmers are the socioeconomic characteristics of the farmers, including age, education and level of experience.

### *Input use and socioeconomic variables of rice farmers by technology*

Adoption of improved technologies can lead to the desired result in agricultural production only if farmers comply with the recommendations and requirements of the technologies, in terms of input use and timing of operations. Any significant deviation from the recommended amount of a particular input can result in lower yields. This section examines critically the amount of inputs committed to rice production in the survey areas during the 2003 rice production season (main season). The data were disaggregated into farmers using traditional and improved technology. The analysis involved computation of means, standard variation, standard error of means and variances, while various tests were carried out to ascertain the quality of data and level of significant difference in the estimates from the two sets of technology data. The various tests included the One-sample T-test, Levene's test for equality of variances and independent sample T-test for equality of means.

The traditional technology farmers are those farmers using hoes and cutlasses and planting traditional rice varieties. These traditional varieties were domesticated by the farming communities long ago, so that farmers have gotten used to them and are not ready to abandon them. The improved technology rice farmers, on the other hand, are the medium- to large-scale farmers who adopted mechanized rice cultivation and planted the improved seed varieties. The improved seed varieties are mainly the FARO types developed by the research institutes in the country. They have been subjected to various field trials and were released to the farmers through the extension system of the state agricultural development programmes (ADPs).

## CONCLUSION

Analysis of the socioeconomic characteristics showed that the two groups of Nigerian rice farmers – those who cultivate traditional rice varieties and those who cultivate improved varieties – share relatively the same characteristics except for farming experience and the number of visits by extension agents. As for technical efficiency differentials between the two groups of farmers, the analysis revealed that the majority of both groups of farmers operate on a small and medium scale, cultivating between less than 1 hectare and fewer than 10 hectares. The results also highlighted the continuous dependence of Nigerian farming on labour input, with the traditional technology rice farmers using more labour than the improved technology farmers. This has serious implications for efficiency, particularly among the improved technology farmers, and may be compounded by the fact that the cost of labour is becoming almost unbearable because of scarcity, on the one hand, and increases in public wages on the other, which tend to draw labour away from the rural areas. The improved technology rice farmers planted about half the quantity of seed as their traditional counterparts. This may be because a smaller quantity of good quality seed is required per hectare as against the low quality traditional varieties with high incidence of unviable seeds. The study also revealed that although the improved technology rice farmers applied more fertilizer per hectare than the traditional technology group, they both applied less than the recommended amount.

The traditional technology rice farmers applied more herbicides per hectare than their improved technology counterparts. This may be due to the high incidence of weeds in traditional rice variety farms. It is worth noting, however, that most of the pesticides that are used are not produced in the country and therefore the supply is subject to variation. The problem arises when pesticides are not applied on time, which can sometimes lead to high incidence of pests and diseases, and seriously affect the yields.

The result of frontier analysis indicated that farm size was the most significant determinant of technical efficiency. Other variables that contributed to technical efficiency included hired labour, herbicides and seeds. Education and farming experience were found to influence technical efficiency in traditional technology rice farms. Output expansion through extensive cultivation of land has a lot of implications for environmental sustainability. Increased farm wage rate will also affect the use of hired labour. In terms of distribution of technical efficiency among the farmers, the result showed that the distribution was highly skewed in both cases, with over 75% and 60% of the farmers having their technical efficiency above 0.9 in the traditional and improved technology groups, respectively. The average technical efficiency in each case was about 0.9 or 90%. This indicates that in spite of the low yield in each case as compared with their counterparts in other African countries such as Côte d'Ivoire and Senegal, there is little opportunity for increased technical efficiency in either group. This may be a result of the fact that the potential absolute frontier is low among Nigerian rice farmers. Thus, unless something is done to shift the potential absolute frontier, the present efficiency levels of Nigerian rice farmers may be too low to ensure competitiveness.

Finally, the test of hypotheses accepted equality of mean for family and hired labour use but rejected equality of mean for age, education and contact with extension agents. The hypothesis for equality of mean in technical efficiency between the two group was also accepted, which indicated that the improved technology rice farmers are not more technically efficient than their traditional technology counterparts.

### *Policy implications*

The comparatively low scale of rice production may seriously undermine the current policy of government to encourage output expansion through large-scale rice farming. Because labour was identified as a major input in rice production in Nigeria, policy attention should be directed towards providing labour saving technology to ease farm operations. Moreover, the low use of fertilizers may be responsible for the low yields recorded by the improved technology farmers. If the link here is with the supply of the commodity, then low levels of fertilizer application may likely be traced to the scarcity and irregular supply of the product due to government subsidy, which encourages hoarding of the goods. Since fertilizer constitutes the most critical input in rice cultivation, erratic supply and high cost of the input will affect the rice expansion programme. This suggests the need to completely liberalize the procurement and distribution of fertilizer.

Overall, the low level of efficiency and lack of competitiveness of Nigerian rice farmers raises the question of whether decades of improved rice development programmes in Nigeria have produced the much desired or expected upward shift in yield that would be expected from adoption of improved seed varieties.

## References

Adesina, A.A. and K.K. Djato. 1997. "Relative efficiency of women as farm managers: Profit function analysis in Côte d'Ivoire". *Journal of Agricultural Economics,*16: 47–53.

Aigner, D.J. and S.F. Chu. 1968. "On estimating the industry production function" *American Economic Review,* 58: 826–39.

Aigner, D.J., A.K. Lovell and P. Schmidt. 1977. "Formulation and estimation of stochastic production function models". *Journal of Econometrics,* 6: 21–34.

Ajibefun, I.A. and A.G. Daramola. (2003). *Efficiency of Micro-Enterprise in the Nigerian Economy.* Research Paper No. 134, African Economic Research Consortium. Nairobi, Kenya.

Ajibefun, I.A. and O.A. Abdulkadri. 1999. "An investigation of technical efficiency of farmers under the National Directorate of Employment in Ondo State, Nigeria". *Applied Economics Letter,* 6: 111–14, Routledge, London.

Ajibefun, I.A., G.E. Battese and A.G. Daramola. 1996. "Investigation of factors influencing technical efficiency of smallholder croppers in Nigeria". *CEPA Working Papers,* No 10/96. Department of Econometrics, University of New England, Amidale, Australia.

Akpokodje, G., F. Lancon and E. Olaf. (2002). "Nigeria's rice policy and development: A review". Final draft. West African Rice Development Association, Abidjan, Côte d'Ivoire.

analytical study". In *Increasing Productivity in Nigeria: Proceedings of the First National Conference on Productivity*, 1–3 December , 1987, Nigeria.

Bagi, F.S. (1982). "Relationship between farm size and technical efficiency in West Tennessee agriculture". *Southern Journal of Applied Economics*, 14: 139–44.

Bagi, F.S. and C.J. Huang (1983). "Estimating production technical efficiency for individuals farms in Tennessee". *Canadian Journal of Agricultural Economics*, 31: 249–56.

Battese, G.E. and G.A. Tessema. (1993). "Estimation of stochastic frontier production function with time-varying parameters and technical efficiency using panel data from Indian villages". *Working Papers in Econometrics*, University of New England, Armidale, Australia. Working Paper No.1: 31pp.

Battese, G.E. and H. Sarfaz. (1998). "Technical efficiency of Cotton farmers in Vehari District of Punjab Pakistan." CEPA Working Paper No. 8 / 98. Department of Econometrics, University of New England, Armidale, Australia.

Battese, G.E. and T.J. Coelli. (1988). "Prediction of farm level technical efficiencies with a generalized frontier production function and panel data". *Journal of Economics,* 38: 387–99.

Battese, G.E. and T.J. Coelli. (1995). "A model for technical inefficiency effect in stochastic frontier production function for panel data". *Empirical Economics*, 20: 325–32.

Bauer, P.W. (1990). "Recent development in econometric estimation of frontier". *Journal of Econometrics,* 38: 387–99.

Ben-Belhassen, B. (2000). "Measure and explanation of technical efficiency in Missouri hog production". *Selected Paper, America Agricultural Economics Association.* Annual Meeting, Tampa, Florida, 30 July–2 August.

CBN. (1999). *Annual Report and Statement of Accounts*. Central Bank of Nigeria, Abuja.

Chuta, E. (1984). "Policies and programmes for small scale industries in Nigeria: Relevance for rural industrialization". In E. Chuta and S.V. Sethuroma, eds., *Rural Small- Scale Industries and Employment in Africa and Asia.* Geneva: International Labour Organization.

Coelli, T.J. (1996). "A guide to FRONTIER Version 4.1: A computer program for stochastic frontier production and cost function estimation". CEPA Working Paper 96/07. University of New England, Armidale, Australia.

Coelli, T.J. and G.E .Battese. (1996). "Identification of factors which influence the technical efficiency of Indian farmers". *Australian Journal of Agricultural Economics*, 40: 103–28.

Dawson, P.J., J. Lingard and C.H. Woodford. (1991). "A generalized measure of farm specific technical efficiency". *America Journal of Agricultural Economics.* 2: 26: 1098–104.

Debreu, G. (1951). "The coefficient of resource utilization". *Econometrica,* 19: 273–92. Federal Ministry of Agriculture and Rural Development. 2001. *Crop, Area and Yield Survey, 2001.*

Ellul, J. (1965). *The Technological Society*. New York: Knopf .

FAO. (2000). *Rice Information,* Vol. 2. Rome: Food and Agricultural Organization FAO. 2001. *Rice Statistics.* Website http://www.Riceweb.org.

Farrell, M.J. (1957). "The measurement of productive efficiency". *Journal of the Royal Statistical Society,* A 120: 253–81.

FGN. ( 1985). *Agricultural Policy for Nigeria.* Ministry of Agriculture and Natural Resources. Abuja, Nigeria.

FGN. (2000). *Agricultural Policy for Nigeria: Reprint.* Ministry of Agriculture and Natural Resources. Abuja, Nigeria.

Greene, W.H. (1980). "Maximum likelihood estimation of econometric frontier functions".

Hardcastle, J.E. (1959). "The development of rice production and research in the Federation of Nigeria". *Tropical Agriculture*, 36: 79–95.

Heshmati, A. and Y. Mulugata. (1996). "Technical efficiency of the Uganda matoke farms". *Applied Economic Letters,* 3: 491–94.

Huang, C.J, and J.T. Liu. (1994). "Estimation of a non-neutral stochastic frontier production function". *Journal of Productivity Analysis,* 4: 171–80.

Imolehin, E.D. (1991a). "Coordinated rice evaluation trials (CRET) report". Unpublished TechnicalReport.

Imolehin, E.D. (1991b). "Rice improvement and production in Nigeria". Paper presented at WARDA Upland Breeding Task-Force Workshop, Bouake, Côte d'Ivoire, 26, August 1991.

Indonesian weaving industry". *Journal of Development Economics*, 9: 234-45.

IRRI, (1995): *World Rice Statistics*, pp 34–42. International Rice Research Institute.Metro Manila, Philippines.

Jondrow, J., C.A. Lovell, I. Materov and P. Schmidt. (1982). "On the estimation of technical inefficiency in the stochastic frontier production function model". *Journal of Econometrics,* 19: 233–38.

*Journal of Econometrics,* 13(1): 27–56.

*Journal of Econometrics,* 22: 245–68.

Kalirajan, K. (1981a). "An econometric analysis of yield variability in paddy production". *Canadian Journal of Agricultural Economics*, 29: 283–94.

Kalirajan, K. (1981b). "The economic efficiency of farmers growing high yielding, irrigated rice in India". *American Journal of Agricultural Economics,* 63(3): 566–69.

Kalirajan, K. and J.C. Flinn. (1983). "Measurement of farm specific technical efficiency".

Khan, M.H. and D.R. Maki. (1979). "Effects of farm size on economic efficiency: The case of Pakistan". *American Journal of Agricultural Economics,* 61(1): 64–9.

Koopmas, T.C. (1951). "An analysis of production as an efficient combination of activities". In T.C. Koopmas, ed., *Activity Analysis of Production and Allocation*. Cowles Commission for Research in Economics, Monograph No. 13. New York: Wiley.

Kumbhakar, S.C. and A. Heshmati. (1995). "Efficiency measurement in Swedish dairy farms: An application of rotating panel data 1976–1988". *American Journal of Agricultural Economics,* 77(3): 660–74.

Kumbhakar, S.C., S. Ghosh and J. T. McGuckin. (1991). "A generalized production frontier approach for estimating determinants of inefficiency in US dairy farms". *Journal of Business and Economic Statistics*, 9: 279–86.

Lau, L.J. and P.A. Yotopolous. (1971). "A test for relative efficiency and application to Indian agriculture". *American Economic Review,* 61: 94–109.

Lee, L.F. (1983). "A test for distributional assumption for the stochastic frontier functions".

Lewin, A.Y. and C.A.K. Lovell. (1990). "Editor's introduction". *Journal of Econometrics*, 46: 3–5.

Lyubov, A.K. and H.H. Jensen. (1998). *Technical Efficiency of Grain Production in Ukraine*. Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa.

Meller, J.P. (1976). *Efficiency Frontier for Industrial Establishments of Different Sizes*. *Explorations in Economic Research.* Occasional paper of the National Bureau of Economics Research.

Mochebele, M.T. and A. Winter-Nelson. (2002). "Migrant labour and farm technical efficiency in Lesotho". *World Development,* 28(1): 143–53.

Obwona, M. (2000). "Determinants of technical efficiency among small and medium scale farmers in Uganda: A case of tobacco growers". Final report presented at AERC Biannual Research Workshop, Nairobi, Kenya. 27 May - 2 June 2000.

Ogundele, O.O. (2003). "Technology differentials and resource-use efficiency in rice production in Kaduna State, Nigeria". Unpublished PhD thesis. Department of Agricultural Economics, University of Ibadan, Nigeria.

Ogunfowora, O.M., S.M. Essang and S.O. Olayide. (1974). "Resource productivity in traditional agriculture. A case study of Kwara State". *Journal of Rural Economics,* 9(2): 119–27.

Olaf, E., F. Lancon, S.O. Akande, S.O. Titilola, G. Akpokodje and O.O. Ogundele. (2002). "Rice production systems in Nigeria: A survey". In *The Nigerian Rice Economy in a Competitive World: Constraints, Opportunities and Strategic Choices*. Final Draft. WARDA, Abidjan, Côte d'Ivoire. Unpublished.

Olayide, S.O. (1980). "Agricultural technology and Nigerian small farmers". In S.O. Olayide, J.A. Eweka and V.E. Bello-Osagie, eds., *Nigerian Small Farmers: Problems and Prospects in Integrated Rural Development*. Centre for Agricultural Research and Development (CARD). University of Ibadan, Nigeria.

Oludimu, O. (1987). "Investment, productivity and quality of life in rural area society. An

Omotayo, A., O.D. Chikwendu and K. Adebayo. (2001). "Two decades of World Bank assisted extension services in Nigeria: Lessons and challenges for future". *Journal of Agricultural Education and Extension,* 7(3): 143–52.

*Pakistan Journal of Applied Economics*, 2: 167–80.

Parikh, A., F. Ali and M.K. Shah. (1995). "Measurement of economic efficiency in Pakistani agriculture". *American Journal of Agricultural Economics*, 77: 675–85.

Pitt, M. and L. Lee. (1981). "The measurement and sources of technical inefficiency in

Project Coordinating Unit (PCU). (2001). "Crop area yield survey (CAY)". Federal Ministry of Agriculture and Rural Development, Abuja.

Project Coordinating Unit (PCU). (2002). "Crop area yield survey (CAY)". Federal Ministry of Agriculture and Rural Development, Abuja.

Project Coordinating Unit (PCU). (2003). "Crop area yield survey (CAY)". Federal Ministry of Agriculture and Rural Development, Abuja.

Reifschneider, D. and R. Stevenson. (1999). "Systematic departures from the frontier: A framework for the analysis of firm inefficiency". *International Economic Review,* 32: 715–23.

Richmond, J. (1974). "Estimating the efficiency of production". *International Economic Review,* 15: 515–21.

Schmidt, P. and T.F. Lin. (1984). "Simple tests of alternative specifications in stochastic frontier models". *Journal of Econometrics,* 24: 349–61.
Seiford, L.M. and R.M. Thrall. (1990). "Recent development in data envelopment analysis:
Seyoum, E.T., G.E. Battesse and E.M. Fleming. (1998). "Technical efficiency and productivity of maize producers in Eastern Ethiopia: A case study of farmers within and outside the Sasakawa Global 2000 Project". *Agricultural Economics,*19: 341– 48.
The mathematical programming approach to frontier analysis". *Journal of Econometrics,* 46: 7–38*.*
Townsend, R.F., J. Kirsten and N. Vink. (1998). "Farm size, productivity and return to scale in agriculture revisited: A case of wine producers in South Africa". *Agricultural Economics*, 19: 175–80.
Upton, M. (1972). *Farm Management in Nigeria*. Occasional Paper*.* Department of Agricultural Economics, University of Ibadan, Nigeria.
Weir, S. and J. Knight. (2000). "Education Externalities in Rural Ethiopia: Evidence from average and stochastic frontier production functions". Working Paper No. 4, 2000. Centre for Study of African Economies, University of Oxford.
West Africa Rice Development Association and Nigerian Institute of Social and Economic Research. 2001. *Report of the Stakeholders Workshop.* Ibadan, Nigeria, 8–9 November.
World Bank 1997. Research Highlights. National Agricultural Research Project (NARP) Annual Report. The World Bank, Washington, D.C.
Yao, S. and Z. Liu. (1998). "Determinant of grain production and technical efficiency in China". *Journal of Agricultural Economics,* 49(2): 171–84.