Applied Tropical Agriculture
Volume 21, No.1, 24-32, 2016.

Adoption of Improved Rice Varieties and its Impact on Multi-Dimensional Poverty of Rice Farming Households in Nigeria

Adenuga A.H. [1,4*], Omotesho O.A.[1], Ojehomon V.E.T.[2], Diagne, A.[3], Ayinde O.E.[1] and Arouna A.[3]

[1]Department of Agricultural Economics and Farm Management, University of Ilorin, Ilorin, Kwara State, Nigeria.
[2]National Cereals Research Institute (NCRI) Badeggi, Bida, Niger State, Nigeria.
[3]Impact Assessment and Policy Unit, Africa Rice Centre, Cotonou, Benin Republic.
[4]Gibson Institute for Land Food and Environment, School of Biological Sciences, Queen's University Belfast, United Kingdom.
*Corresponding Author: aadenuga01@qub.ac.uk

ABSTRACT

*This study evaluated the impact of improved rice varieties adoption on the multidimensional poverty index of rice farming households in North Central Nigeria. Stratified random sampling technique was employed to select 149 rice farming households in the study area. Data were collected by trained enumerators using Mlax application installed in tablet computers. Descriptive statistics, Alkire and Foster Multidimensional Poverty Index methodology and the Local Average Treatment Effect (LATE) Model were the major analytical tools employed in analyzing the data. The multidimensional poverty index for the adopters and non-adopters of improved rice varieties were estimated as 0.32 and 0.40, respectively. LATE result showed that improved rice varieties adoption significantly reduced multidimensional poverty index of the rice farming households by 0.18. Generally, the result**s** of the study showed that poverty is more intense among non-adopters of improved rice varieties than adopters and the adoption of improved rice varieties has a negative and significant impact on multidimensional poverty. Consequently, efforts should be made by the government and development institutions to ensure increased access of rice farming households to improved rice seeds varieties to encourage its adoption.*

Keywords: Multidimensional Poverty Index; Local Average Treatment Effect; Alkire and Foster Methodology; Nigeria.

INTRODUCTION

Rice serves as an important staple food in the diet of an estimated 168 million Nigerians (Erhabor and Ojogho 2011; Daramola, 2005). In recent years, rice production in the country has been expanding at the rate of 6% per annum, with 70% of the production increase due mainly to land expansion and only 30% being attributed to an increase in productivity (AfricaRice, 2007; Okoruwa *et al*., 2007). Rice production in Nigeria is dominated by smallholder farmers who use traditional methods that are characterised with problems of low productivity (Tsado *et al*., 2014). Productivity increase in the last four decades is centered on increasing the number of new varieties and a positive and increasing trend in the rate of adoption of modern varieties (Simtowe *et al*., 2012). Though increases may not wholly be attributed to varietal improvement, their steady increase in rice production in the past four decades provide further evidence that there is potential for further improvement in productivity (Simtowe *et al*., 2012). It is believed that the access to and adoption of improved rice seed varieties would go a long way in raising the productivity of small-scale rice farmers and consequently improve their livelihood. According to Adekambi *et al*. (2009), productivity increase in agriculture has the capability of reducing poverty through increase in farmers' income and reduction in food prices. Seed is the key input in agriculture and to a great extent the yield and quality of the crop depend on the quality of the seed planted (Awotide *et al*., 2012).

Nigeria, though endowed with abundant human, capital and natural resources, has remained one of the poorest countries in the world **(**Kalu and Nenbee 2013; Adejuwon and Tijani, 2012). About 100 million Nigerians live on less than $1 per day and the country was ranked 142nd poorest country out of 175 countries in 2010 by the United Nations Human Development Index (IFAD, 2012; NBS, 2011). The percentage of Nigerians living in absolute poverty, rose to 60.9% in 2010, compared to 54.7% in 2004, the situation being more severe in North-Western and North-Eastern part of the country where a staggering 77.7% and 76.3% respectively, of the population are poor (NBS, 2011). Income inequality has also risen from 0.429 in 2004 to 0.447 in 2010 (NBS, 2011)**.** The Federal Office of Statistic and World Bank in their analysis of the poverty trend in Nigeria have shown that poverty is more prevalent in rural

farming households (Adeolu and Taiwo, 2004; Kudi *et al*., 2008).

World Bank (2000) defined poverty as pronounced deprivation in well-being, and comprises many dimensions. It includes low incomes and the inability to acquire the basic goods and services necessary for survival with dignity (Alkire and Santos, 2010). Poverty is not only a state of existence but also a process with many dimensions and complexities (Khan, 2000). Despite the huge investments and numerous programmes embarked upon by the Nigerian government and developmental agencies over the years to increase rice production in the country and improve the livelihood of the farmers, the average Nigerian rice farmer remains poor. The deprivations experienced by the farmers are more than just income poverty. Poverty is a multi-dimensional phenomenon for which causes, conditions, and consequences remain difficult to identify and quantify (Ferreira and Lugo 2012; Alkire and Santos, 2010**).** There is no empirical research in Nigeria to the best of our knowledge relating technology adoption to multidimensional poverty. This is mainly due to lack of appropriate methods to link adoption to multidimensional poverty as most previous research have failed to move beyond estimating income poverty (Awotide *et al.,* 2012; Adekambi *et al*., 2009). Besides, most impact studies do not properly control for potential differences between technology adopters (participants) and farmers in the comparison group (non-adopters or non-participants), making it difficult to draw definitive conclusions. In view of the foregoing, this study was carried out to: determine the level of adoption of improved rice varieties in north central Nigeria, estimate the multidimensional poverty index of improved rice adopters and non-adopters and estimate the impact of adoption on multidimensional poverty index of small-scale rice farmers in the study area.

METHODOLOGY

Study Area

The study was carried out in Nasarawa and Benue states' rice hub in Nigeria which was purposively selected because of the high level of rice production activities across the rice value chain in the area (Tollens *et al.,* 2013). Rice Sector Development Hubs are zones where rice research outputs are integrated across the rice value chain to achieve development outcomes and impact (Tollens *et al.,* 2013). The Nasarawa and Benue states' hub is made up of four Local Government Areas of Guma and Gwer-west in Benue state and Lafia and Obi Local Government Areas in Nasarawa state. Benue state is located within longitude 7°47' and 10°0' East and Latitude 6°25' and 8°8' North while Nasarawa state is located within 8°32′ and 8.533°North and 8°18′ and 8.3°East (Wikipedia, 2013)**.** Rainfed upland and rainfed lowland rice are the major rice varieties popularly grown in the study area. Both states share a common boundary and have rich and diverse agricultural produce which include rice, yams, beans, cassava, potatoes, maize, soya beans, sorghum, millet and coco-yam.

Sources of Data

The study made use of primary data from the NCRI/AfricaRice baseline survey during which tablet computers, in which the survey questionnaire is downloaded, were used to obtain information from local rice farmers. Africa Rice Centre in 2012 developed the Mlax application on Tablets and Smartphones which was used to collect the data for this study. The Mlax survey application installed in the tablet computers is well suited for socioeconomic data collection. It is designed in such a way that data collected are sent to the server automatically by simply connecting to the internet and running the application. Data can then be converted and downloaded in STATA software format for analysis (for more information on the Mlax application see Mohanty *et al*., 2014). The data was collected by 9 trained enumerators who read the questions to the farmers and input their responses into the tablet computers. Primary data relating to the socioeconomic and demographic characteristics of the farmers, farmers' knowledge of rice varieties and varieties cultivated, welfare and farm characteristics of the respondents were collected.

Sampling Technique

The study employed a stratified random sampling technique. A list of all villages (obtained from the Benue and Nasarawa Agricultural Development Project (ADP)) in the hub (the 4 LGAs) was constructed after which villages were rice is not produced or were rice is not grown in the target ecology were sorted out, so that, only villages were rice is grown were left. All remaining villages where then grouped into 3 homogeneous classes (strata) using village accessibility as a criterion. These are: "villages with good accessibility throughout the year", "villages with poor accessibility" and "villages with very limited accessibility". Accessibility in this context is related to both road condition and distance from an urban area. Due to the high intensity of the field activities, villages with very limited access were not considered. Each of the two remaining village group were then classified into two classes based on dominant crops (rice in the target ecology as major crop and rice in the target ecology as minor crop). The 'accessibility' and 'dominant crop' criteria then resulted into for 4 strata of villages namely: villages with poor access but with rice as major crop, villages with poor access but with rice as minor crop, villages with good access but with rice as major crop and villages with good access but with rice as minor crop. From each of the stratum, 8 villages were randomly selected to make up a total of 32 villages. Five households were then randomly selected from each of the 32 villages such that in total, we had 160 rice farming households. However, only data from 149 households were found useful for analysis. These households were then defined as adopters and non-adopters based on their adoption status. A household was defined as an adopter of a particular variety of rice if it plants that variety in at least one of its rice plots.

Table 1: Dimensions Indicators and Weights

Dimensions	Indicators	Measurements	Weights
Education	Years of schooling	Deprived if no household member has completed 9 years of formal education	1/6
	Child enrolment	Deprived if any school-aged child is not attending school in years 1 to 6	1/6
Standard of Living	Electricity	Deprived if the household has no electricity	1/18
	Drinking water	Deprived if the household does not have access to clean drinking water or clean water is more than 30 minutes' walk from home	1/18
	Sanitation	Deprived if they do not have an improved toilet or if their toilet is shared	1/18
	Housing	Deprived if hut/house/ has a dirt, sand or dung floor or is built with sub-standard material	1/18
	Cooking fuel	Deprived if they cook with wood, charcoal or dung	1/18
	Assets	Deprived if the household does not own more than one of: radio, TV, telephone, bike, or motorbike, and do not own a car or tractor	1/18
Health	Health care quality	Deprived if the household does not have access to quality health care	1/6
	Health as a Limiting factor	Deprived if health is a limiting factor in most regular activities	1/6

Method of Data Analysis

Various analytical tools and procedures were employed in this study. Descriptive statistics such as percentages, frequencies, means and standard deviation were used to explain the demographic and socio-economic characteristics of the respondents. The Alkire and Foster Measure (AFM) of estimating multidimensional poverty index (Alkire and Foster, 2007) and the paired t-test were respectively used to calculate and compare the multidimensional poverty indices of the two groups of rice farming households. To analyse the impact of adoption of improved rice varieties on the multidimensional poverty index of the rice farmers, the Local Average Treatment Effect (LATE) model was adopted.

Multidimensional Poverty Index

The AFM (Alkire and Foster, 2007) is a robust measure as it is specifically designed for categorical/ordinal data. The measure has been recently used to obtain the multidimensional poverty indexes (MPI) for different groups of population (Alkire and Santos, 2010). AFM satisfies axioms such as decomposability (useful in targeting population subgroups) and dimensional monotonicity (poverty level should rise whenever a poor person becomes deprived in an additional dimension) (Rahman *et al*., 2005; Decancq and Lugo, 2008; Alkire and Foster, 2011).

Dimensions, indicators and deprivation cutoffs

The MPI uses ten indicators belonging to three dimensions (Health, Education and Standard of Living): two for health, two for education and six for living standards. Households' scores in these dimensions determine the level of achievement of the households. Table 1 summarizes the dimensions, indicators, thresholds and weights used in the MPI (for more on the dimensions and indicators see Adenuga *et al*., 2013).

The notation

Let $y= [y_{ij}]$ denote the (n x d) matrix of achievements, where n represents the number of rice farming households, d is the number of dimensions, and $y_{ij} \geq 0$ is the achievement of household i= 1, 2…..,n in dimension j= 1,2,…d. Each row vector $y_{ij} = y_{i1}, y_{i2},…., y_{id}$ lists the household's i's achievements, while each column vector $y_{ij} = y_{1j},y_{2j},….y_{nj}$ gives the distribution of dimension j achievements across the set of rice farming households. A vector $z = (z_1,…,z_d)$ of deprivation cutoffs (one for each dimension) is used to determine whether a household is deprived. If the household's achievement level in a given dimension j falls short of the respective deprivation cut off zj, the household is adjudged not deprived in that dimension; if the household's level is at least as great as the deprivation cutoff, the household is not deprived in that dimension.

The maximum score is 100%; with each dimension equally weighted (thus the maximum score in each dimension is 33.3 percent). Each indicator within a dimension is also equally weighted. A cut-off of 33.3%, which is the

equivalent of one-third of the weighted indicators, is used to distinguish between the poor and non-poor. This implies that if C is 33.3% or higher, that household is multi-dimensionally poor. Households with a deprivation score greater than or equal to 20% but less than 33.3% are vulnerable to or at risk of becoming multi-dimensionally poor. Households with a deprivation score of 50% or higher are severely multi-dimensionally poor. Following Yalonetzky (2011), the deprivation headcount (H_o) and the dimension adjusted head count (M_o) model is given as follows (equations i – iii)

Estimation of the impact of adoption of Improved Rice Varieties

To appropriately measure the impact of improved rice technology adoption, the design of the right counterfactual is very essential. The counterfactual analysis is based on a fundamental characteristic that some people adopt a particular agricultural technology while others do not in a particular setting, village, or geographical area (Imbens and Wooldridge, 2009; Heckman and Vytlacil, 2005; Ojehomon, *et al*., 2012). This is because farmers who adopt the technology are likely to be different from the non-adopters in ways that are unobserved to the researcher. The selection bias problem emanates from the fact that most programme interventions are targeted at specific groups with specific characteristics and that the intervals targeted are not randomly selected (Simtowe *et al*., 2012). To resolve this problem, it is important to ensure comparability between adopters and non-adopters in terms of their pre-intervention characteristics.

This study used 'the non-parametric Local Average Treatment Effect (LATE)' framework to consistently estimate the causal effect of adoption of improved rice varieties on the multidimensional poverty index of rice farming households. The LATE model is preferred because it guides against the problem of selection bias and non-compliance or problem of endogeneity (Ito, 2007). However, for the purpose of comparison, other techniques such as the mean difference test, Average Treatment Effect (ATE) using Inverse Propensity Score Weighting (IPSW) were also employed. The LATE specification is given as follows (equations iv – vi):

This approach helps to remove both overt and hidden biases and deal with the problem of endogenous treatment. It assumes the existence of at least one variable z called "*instrument"* that explains treatment status but has no direct influence on the outcomes Y_1 and Y_2, once the effects of the covariates **X** are controlled (Awotide *et al*., 2012; Ito, 2007). D_1 and D_0 are binary variables designating the two potential adoption status of the farmer with and without exposure to improved rice varieties (with D_1 indicating adoption and D_0 otherwise).

$$H_o\,(X; k; Z) \equiv \frac{1}{N}\sum_{n=1}^{N} I\,(Cn \geq k) = \frac{q}{N} \quad \text{..... (i)}$$

$$A\,(X; k; Z) \equiv \frac{\sum_{n=1}^{N} I\,(Cn \geq k)Cn}{q} = \frac{\sum_{1}^{q} c}{q} \quad \text{.....(ii)}$$

$$M_o = H_o \times A \quad \text{.....(iii)}$$

Where: H = Head count ratio; A = Average intensity of deprivation; M_0 = Adjusted headcount ratio or the Multidimensional Poverty Index (MPI); q = the number of people who are multi-dimensionally poor; N= Total population; C= is the deprivation score that the poor experience; I ( ) = indicator that takes the value of 1 if the expression in parenthesis is true. Otherwise it takes the value of 0.

$$E(Y_1 - Yo/D=1) = LATE = \frac{cov(Y,z)}{cov(D,z)} \quad \text{.....(iv)}$$

$$= \frac{E(Y|z=1) - E(Y|z=0)}{E(D|z=1) - E(D|z=0)} \quad \text{.....(v)}$$

$$= \frac{E[Y_i .(z - E[z_i])]}{E[YD_i .(z - E[z_i])]} \quad \text{..... (vi)}$$

RESULTS AND DISCUSSION

The summary of the socio-economic characteristics of the rice farming households is given in Table 2. The average age of the adopters and non-adopters of improved rice varieties was 50 years and 46 years, respectively. The modal age group for both the adopters and non-adopters of was 41-50 years. The average household size for adopters was 8 persons while it was 7 persons for non-adopters. The relatively large family size for both groups is an indication that the rice farmers probably have access to family labour. About 32% and 40% of the adopters and non-adopters respectively had no formal education. Although the proportion of non-adopters with tertiary education (40%) is higher than for adopters (13%), more of the adopters (69%) have at least one form of education compared to the non-adopters (60%). The result is similar to that obtained by Awotide *et al*. (2012). The proportion of females involved in rice farming in the study area was only 12% and all of them were adopters of improved rice varieties. This implies that female involvement in rice farming in the study area was low. The result showed that none of the non-adopters of improved rice varieties had access to credit while only 11% of the adopters had access to credit and more than 60% of those that had access to credit obtained it from informal sources. Similar result had been obtained by Kotu *et al.* (2000) and Chekene and Chancellor (2015).

For both groups, more than 80% of the respondents had agriculture and other allied activities as their primary occupation and only about 40% are members of association. The average farm size for the adopters of improved rice varieties was 2.82 hectares while that of non-adopters was 4 hectares. The large land holding of the non-adopters could be attributed to the existence of large family land on which they grow a particular variety the family may be known for. This result is similar to that obtained by Zegeye (2001) in which the average farm size of non-adopters of improved wheat seed varieties was larger than that of adopters. Only 14% of the adopters had access to agricultural training while for the non-adopters, its only 20%.

Multidimensional Poverty Index

Indicators of Multidimensional Poverty among Rice Farmers

The incidences of deprivation across the multidimensional poverty indicators of the rice farmers by their adoption status are presented in Table 3. The result shows that both the adopters and non-adopters of improved rice varieties suffer high deprivation in the standard of living dimension. Within this dimension, about 98% of both groups are deprived in the cooking fuel indicator. The next indicator within the standard of living dimension for which the farmers are highly deprived is the sanitation indicator (about 89% for both groups). The farmers suffer the least deprivation in asset indicator in the standard of living dimension. This result corroborates the findings of the National Bureau of Statistics (NBS, 2011) that about 60 percent of Nigerians live below the poverty line and that it is more severe in the northern part of the country where this study was carried out.

Table 2: Summary of Socio-economic characteristics of the respondents

Characteristics	Adopters (%)	Non-Adopters (%)	Total (%)
Average Age Household Head (years)	50.41	46.8	50.17
Average Household Size	9	7	8
Educational Level of Household Head			
No Formal Education	31.65	40	32.21
Quranic Education	6.47	0	6.04
Primary Education	20.86	20	20.81
Junior secondary Education	7.91	0	7.38
Senior secondary Education	20.14	0	18.79
Tertiary Education	12.95	40	14.77
Marital Status			
Married	87.05	100	87.92
Single	0.72	0	0.67
Widow/Widower	12.23	0	11.41
Proportion of Male Rice Farmers	87.05	100	87.92
Proportion of Female Rice Farmers	12.95	0	12.08
Households with credit Access	11.51	**0**	10.74
Households with Agriculture as Primary Activity	87.05	80	86.58
Average Farm Size (ha)	2.82	4	2.90
Proportion of Households with Off Farm Income	53.69	20	48.32
Proportion of Households with Access to Agricultural Training	13.67	20	14.09
Membership of Association	43.17	40	42.95

Table 3: Incidence of deprivation across indicators by adoption status

Dimensions	Adopters		Non-Adopters		Total	
	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage
Education						
Basic Education	30	21.58	0	0	30	20.13
Enrollment	22	15.83	3	30	25	16.78
Health						
Quality Health Care	62	44.60	8	80	70	46.8
Sickness	26	18.71	4	40	30	20.13
Standard of Living						
Electricity	106	76.26	9	90	115	77.18
Clean Water	84	60.43	10	100	94	69.03
Sanitation	124	89.21	10	100	134	89.93
Housing	40	28.78	0	0	40	26.85
Cooking fuel	137	98.56	10	100	147	98.66
Asset	40	28.78	1	10	41	27.52

The farmers seem to be better off in the education dimension. As shown in table 3 only 15% and 16% of adopters and non-adopters respectively are deprived in child enrolment indicator. This low deprivation status in the education dimension could be attributed to drive by the Universal Basic Education (UBE) programme of the government to achieve the millennium development goal in education through free and compulsory basic education programme. For the health dimension, access to quality health care is the indicator for which both groups were most deprived. About 50% of the respondents in both groups do not have access to good quality healthcare. Very few households were found to have no deprivation at all in both groups. Most of households are deprived in one to six indicators.

Poverty and Deprivation Count of Rice Farmers by Adoption Status

A household is declared multidimensionally poor if its multidimensional poverty index exceeds the minimum cut-off point (k) of 33.3% or 0.33 at k= 3 and 20% or 0.2 at k=2. Table 4 presents the estimated poverty index based on the value of the cut-off, k. It can be observed from the table that the poverty measures decreases with the level of k. This agrees with the findings of Batana (2008) and Adeoti and Popoola (2012). Generally, the result**s** indicate that poverty is more intense among non-adopters of improved rice varieties than adopters. For example, when k= 3, the non-adopters of improved rice varieties are deprived in 55% of the dimensions while the adopters are deprived in 48% (Table 4). As shown in the Table 4, at the poverty line (k=3), 66% of adopters of improved rice varieties are multi-dimensionally poor. The figure is higher for the non-adopters where more than 70% of the farmers were multi-dimensionally poor. This result corroborates the findings of NBS (2011) that about 60% of Nigerians live below the poverty line. The higher value for this study compared to the NBS (2011) value could support the view that poverty is more severe in the northern part of the Nigeria where this study was carried out. However, at the poverty line (k=2), more than 80% of both groups fall below the poverty line with the non-adopters of improved rice varieties having a higher percentage of multi-dimensionally poor people.

Local Average Treatment Effect Model

The results of the of Local and Average Treatment Effect (LATE & ATE) of adoption of improved rice varieties in the study area using inverse propensity score weighting technique are presented in Table 5. The results showed that the adoption of improved rice varieties exerts a negative and significant impact on multidimensional poverty. Specifically, the LATE estimate showed that improved technology adoption significantly reduced the multidimensional poverty index by 0.18 (Table 5). This is the average change in multidimensional poverty index of households resulting from a change in technological status. This finding implies adoption of improved rice varieties contribute to poverty reduction among rice farmers in the study area. The significance at 1% of the F-statistics for the joint significance of the interacted terms as well as the non interacted terms indicates that they are jointly significantly different from zero. These findings are consistent with previous studies on the impact of adoption of improved crop varieties on household welfare. Awotide *et al.* (2012), Donstop *et al.* (2011), Hossain *et al.* (2006) and Mendola (2007) had shown that the adoption of improved rice varieties has a significant positive impact on household income and a negative impact on poverty status. Becerril and Abdulai (2010) using propensity score matching methods also found that improved maize adoption significantly reduces poverty in Mexico. However, all these studies did not take into account the multidimensional of the poverty like this study does.

Table 4: Poverty indices of adopters and non-adopters of improved rice varieties

Parameters	Adopters	Non-Adopters	Total	Mean difference
When K=3				
Multidimensional Headcount (H_0)	0.66	0.72	0.66	
Intensity of Poverty (A)	0.48	0.55	0.48	
Multidimensional Poverty Index (M0)	0.32	0.40	0.32	0.08
When K=2				
Multidimensional Headcount (H_0)	0.84	0.86	0.85	
Intensity of Poverty (A)	0.43	0.43	0.38	
Multidimensional Poverty Index (M0)	0.36	0.37	0.32	0.01

Table 5: Estimates of the impact of adoption of improved rice varieties

Estimation	Parameter	Robust std. Error	Z-value
ATE	-0.09	-0.08	-1.05
ATE1	-0.09	-0.09	-0.99
ATE0	-0.11*	-0.06	-1.74
LATE	-0.18***	0.07	-2.45

Significance level *** P<0.01, **P<0.05, *P<0.10.

CONCLUSION AND RECOMMENDATIONS

Traditional studies on poverty based on a strictly income-based approach have been placed into question in recent years on the basis that poverty is a multidimensional phenomenon. This study provides an ex-post assessment of the impact of adoption of improved rice varieties on the multidimensional poverty index of rice farming households in Nigeria. The study showed that multidimensional poverty measures can be combined with non-experimental program evaluation estimators to assess the overall effectiveness of a research outputs in relation to farmer's welfare. The study has been able to show that adoption of improved rice varieties has a positive impact on the multidimensional poverty status of the rice farming households. In line with the results of the study, it is recommended that the government, development and research institutions should put machineries in place to ensure increased adoption of certified improved rice seeds through effective extension services and improved rice seeds availability. Also, from the result of the study, it can be deduced that all the women in the study population were adopters of improved rice varieties. However the populations of women involve in rice farming in the study area is very low. Women should therefore be encouraged to go into rice production. Proper targeting and training of beneficiaries of interventions would also help improve exposure and adoption and hence improve farmer's welfare.

ACKNOWLEDGEMENT

The Authors are grateful to Africa Rice Centre Cotonou, Benin Republic for funding this research and the National Cereals Research Institute (NCRI), Badeggi, Nigeria for providing the technical support. We also appreciate the useful comments of two anonymous referees.

REFERENCES

Adekambi, S. A. Diagne, A., Simtowe, F. P. and Biaou, G., 2009. The impact of agricultural technology adoption on poverty: The case of NERICA rice varieties in Benin. Paper presented as contributed paper at the 27th Conference of the International Association of Agricultural Economists. Beijing, Chin. 16pp

Adenuga, A. H., Omotesho, O. A. Ojehomon, V. E. T., Diagne, A., Olorunsanya, E. O. and Adenuga O. M. 2013. Poverty Analysis of Rice Farming Households: A Multidimensional Approach. Albanian j. agric. sci. 12 (4): 641-651

Adejuwon, K. D. Tijani, A. A. 2012. Poverty reduction and the attainment of the millennium development goalsin Nigeria: Problems and prospects. International Journal of Research in Social Sciences (IJRSS), 2(2): 53-74.

Adeolu, B.A. and Taiwo, A. 2004. The impact of National Fadama facility in alleviating rural poverty and enhancing agricultural development in South-Western Nigeria. Journal of Social Science, 9(3),:157-161

Adeoti, A. and Popoola, O. 2012. Determinants of Child Poverty in Rural Nigeria: AMultidimensional Approach Global Journal of Human Social Science, Arts and Humanities, 12(12*):* 39-54.

Alkire, S. and Foster, J. 2007. Counting and multidimensional poverty measurement. OPHI Working Paper 7, 33p. University of Oxford. 33pp

Alkire, S. and Santos, M.E. 2010. Acute Multidimensional Poverty: A New Index for Developing Countries. OPHI Working Papers 38, University of Oxford. 139pp

Alkire, S. and Foster, J. 2011b. Understandings and misunderstandings of multidimensional poverty measurement, Journal of Economic Inequality 9 (2): 289-314

Alkire S, Roche J. M. Santos M. E. and Seth S. 2011a. Multidimensional Poverty Index Brief Methodological Note. Oxford Poverty and Human Development Initiative (OPHI), University of Oxford. 14pp

African Rice Centre, 2007. African Rice Trends: Overview of Recent Development in the Sub-Saharan Africa Rice Sector. Africa Rice Center Brief. Cotonou, Benin, West Africa Rice Development Association WARDA. 8pp.

Awotide B. A., Diagne A. and Omonona B.T. 2012. Impact of Improved Agricultural Technology Adoption on Sustainable Rice Productivity and Rural Farmers' Welfare in Nigeria: A Local Average Treatment Effect (LATE) Technique. Paper Presented at the African Economic Conference, Kigali, Rwanda 23pp.

Batana, Y. 2008. Multidimensional Measurement of Poverty in Sub-Saharan Africa. OPHI Working Paper 13, University of Oxford. 35pp

Becerril, J. and Abdulai, A. 2009. The impact of improved maize varieties on poverty in Mexico: A propensity score marching approach. World Development, 38 (7), 1024–1035

Chekene, M. B. and Chancellor, T.S.B. 2015. Factors Affecting the Adoption of Improved Rice Varieties in Borno State, Nigeria. Journal of Agricultural Extension 19(2): 21-33

Tollens E., Demont M., Sie M., Diagne A Saito K., and Wopereis M. C. S. 2013. From WARDA to Africa Rice: An overview of rice research for development activities conducted in partnership in Africa. In Realizing Africa's rice promise, Wopereis M. C. S, Johnson D. E., Ahmadi N., Tollens E., and Jalloh A. (eds) (1-22) pp CABI Publishers, Oxfordshire.

Daramola, B., 2005. Government policies and competitiveness of Nigerian rice economy. Proceedings of the Workshop on Rice Policy and Food Security in Sub-Saharan Africa, Nov. 7-9, WARDA, Cotonou, Republic of Benin, pp: 1-18.

Decancq K. and Lugo, M.A., 2008. Setting Weights in Multidimensional indices of wellbeing, OPHI Working Paper 18 University of Oxford. 34pp

Dontsop-Nguezet, P.M, A. Diagne, V.O.Okoruwa and V.E.T. Ojehomon 2011. Impact of improved rice technology adoption (NERICA varieties) on income and poverty among Rice Farming Households in Nigeria: A Local Average Treatment Effect (LATE) Approach. Quarterly Journal of International Agriculture 50(3), 267-291

Erhabor , P. O. I. and Ojogho O. 2011. Demand Analysis of Rice in Nigeria. Journal of Food Technology, 9(2): 66-74

Ferreira F and Lugo M. A. 2012. Multidimensional poverty analysis: Looking for a middle ground. Society for the study of economic inequality, Working Paper Series, 251. Available at http://www.ecineq.org/milano/WP/ECINEQ2012-251.pdf. Accessed 16th November, 2013.

Heckman, J. and Vytlacil. E., 2005. Structural Equations, Treatment Effects, and Econometric Policy Evaluation. Econometrica, 73:669-738.

Hossain, M. Bose, M.L. and Mustafi, B.A.A. 2006. Adoption and productivity impact of modern rice varieties in Bangladesh. Developing Economies, 64 (2), pp. 149–166.

International Fund for Agricultural Development (IFAD), 2012. Investing in Rural People in Nigeria. Retrieved from http://www.ifad.org/operations/projects/regions/pa/factsheets/ng.pdf on the 16th of May, 2014.

Imbens, G. and Wooldridge, J. M., 2009. Recent Developments in the Econometrics of Program Evaluation. Journal of Economic Literature, 47(1): 5–86.

Ito, S. 2007. A Practical Guide to the Program Evaluation Methods. In: Uchimura, H. (Eds.), Health Service and Poverty: Making Health Services More Accessible to the Poor. IDE-JETRO Joint Research Program Series, Vol. 142. Chiba, Chiba City, pp. 143-203.

Kalu E, Nenbee S. G. 2013. Micro-savings and poverty reduction in Nigeria: Some field observations from Gokana Local Government Area of Rivers State. European Journal of Business and Management, 5(17): 84-91.

Khan M.H., 2000. Rural poverty in developing countries. Finance Development. The International Monetary Fund Publications, 37(4): 23-36.

Kotu, B. H., Verkuijl, H., Mwangi, M. and Tanner, D. 2000. Adoption of Improved Wheat Technologies in Adaba and Dodola Woredas of the Bale Highlands, Ethiopia. Mexico, D.F.: International Maize and Wheat Improvement Center (CIMMYT) and Ethiopian Agricultural Research Organization (EARO) 26pp

Kudi,T. M., Usman, I., Akpoko, J.G and Banta, A.L., 2008. Analysis of the impact of National Fadama Development Project II (NFDP II) in alleviating poverty among farmers in Giwa Local Government Area of Kaduna State, Nigeria. Ozean Journal of Applied Sciences, 1(1): 9 – 15.

Mendola, M. 2007. Agricultural technology adoption and poverty reduction: A propensity score matching analysis for rural Bangladesh. Food Policy, 32 (3), 372–93.

Mohanty S. Arouna A. and Labarta R. 2014. GRiSP Impact Assessment Research, Impact Assessment Focal Point meeting, Minneapolis, USA. Available at http://impact.cgiar.org/sites/default/files//docs/1.4%20GRiSP%20IRRI%20AfricaRice%20CIAT.pdf. Accessed 14th June, 2014

National Bureau of Statistics 2011 Annual socio-economic Report, http://www.nigerianstat.gov.ng/. Accessed 14th June, 2014

Ojehomon V.E.T., Adewumi M.O., Omotesho O.A., Ayinde K., and Diagne A., 2012. Adoption and Economics of New Rice for Africa (NERICA) Among Rice Farmers in Ekiti State, Nigeria. Journal of American Science, 8(2): 423-429

Okoruwa, V.O., Rahji, M. A. Y and Ajani, O. 2007. Rice and Maize Stratification Project in Nigeria. IITA-WA SAKSS and WARDA in conjunction with USAID. 185 pp.

Rahman, T., Mittelhammer, R.C. and Wandschneider, P., 2005. Measuring the quality of life across countries: A sensitivity analysis of well-being indices. WIDER Research Paper 2005/06. 32pp. Available at https://www.wider.unu.edu/sites/default/files/rp2005-06.pdf. Accessed 14th June 2014

Simtowe F., Kassie M., Asfaw S., Shiferaw B, Monyo E., Siambi M. 2012 Welfare Effects of Agricultural Technology adoption: the case of improved groundnut varieties in rural Malawi. Paper presented at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 37pp Retrieved from http://ageconsearch.umn.edu/bitstream/126761/2/Simtowe2.pdf 15th June 2014.

Tsado J. H., Ojo M. A. and Ajayi O. J. 2014 Impact of Training the Trainers' Programme on Rice Farmers' Income and Welfare in North Central, Nigeria Journal of Advanced Agricultural Technologies 1(2):157-160

Wikipedia 2013 http://en.wikipedia.org/wiki/Nasarawa_State. Accessed 31st January, 2013

World Bank. 2000. World Development Report 22684: Attacking Poverty. Oxford University Press, Washington, DC. 356pp.

Yalonetzky G. 2011. Conditions for the most robust poverty comparisons using the Alkire-Foster Family of Measures OPHI Working Paper 44b, University of Oxford. 22pp

Zegeye, T. Taye G., Tanner, D. Verkuijl H., Agidie A., and Mwangi W. 2001. Adoption of Improved Bread Wheat Varieties and Inorganic Fertilizer by Small-Scale Farmers in Yelmana Densa and Farta Districts of Northwestern Ethiopia. Mexico, D.F.: Ethiopian Agricultural Research Organization (EARO) and International Maize and Wheat Improvement Center (CIMMYT). 42pp

*****