Welfare implications of adoption of Fadama III technology among palm oil processors in Nigeria: evidence from Osun state

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ABSTRACT

This study investigated the welfare implications of adoption of Fadama III technology among palm oil processors in Osun state, Nigeria. Multistage sampling procedure was used to select 102 palm oil processors in four Local Government Areas (LGAs) in Osun state. Questionnaire was used to collect data. Data were analysed using descriptive statistics, logistic regression, average treatment effect on the treated (ATT) and double difference estimator. The mean income of Fadama III beneficiaries increased by 25% after the project, while those of non-beneficiaries within Fadama LGAs and non-beneficiaries outside Fadama LGAs increased by 7% and 4% respectively, indicating that the Fadama III beneficiaries had the highest increase in income. Age, years of formal education, sex of household head and access to credit significantly affect the probability of adoption. The ATT results show that being a Fadama III beneficiary increases expenditure by ₦7,105.37, and results from matched double difference estimator show that the expenditure of the beneficiaries increased by ₦4,648.79. Adoption of Fadama III technology had positive effect on the welfare of palm oil processors in Osun state. Hence, such community driven development project as Fadama III should be encouraged and the new Fadama III project with additional financing (AF), which covers all LGAs in Osun state, but streamlined to cassava farmers only, should cover other enterprises.

Keywords: Fadama III project, Technology adoption, Palm oil processing.

INTRODUCTION

The practice of agriculture involves the use of tools and instruments to complement human energy in carrying out activities like tilling, preparing the land for planting, harvesting, storage and processing. Technology, which has been defined as the application of knowledge of nature for achievement of goals, includes the fashioning of instruments, synchronization of activities with nature, use of natural materials and generation of ideas on practices (Adekoya *et al.*, 2012).Research findings have pointed to the fact that the use of new agricultural technology, such as high yielding varieties that kick-started the Green Revolution in Asia, could lead to significant increase in agricultural productivity in Africa and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy (World Bank, 2008). This implies that agricultural productivity growth will not be possible without developing and disseminating cost effective yield-increasing technologies, since it is no longer possible to meet the needs of increasing numbers of people by expanding the area under cultivation or relying on irrigation (Datt and Ravallion, 1996; Hossain, *et al.,* 1992).

In recent times, the paradigm of development widely favoured by development theorists has shifted from the modernisation approach to farmer-centreed strategies. An important component of these strategies includes participatory technology development and transfer, and encouraging interaction among the agricultural knowledge systems, farming systems and indigenous knowledge systems (Akinlade, 2012). Such is the case of the National Fadama Development Projects.The Third National Fadama Development Project (NFDP III) popularly known as Fadama III started in 2008. The project development objective of Fadama III is to increase the incomes of users of rural land and water resources in a sustainable manner throughout the country. By increasing their incomes, the project will reduce rural poverty, increase food security and contribute to the achievement of the first Millennium Development Goal (MDG), which is to eradicate extreme poverty and hunger.

The current levels of agricultural production and agricultural resource productivity in Nigeria show that there is a large need for improvement (Ikpi, 2000). Furthermore, Ikpi (2000) stated that the country's food security index shows that more than 55 percent of her

food needs are imported, while her agro-processing industry imports 61.56 percent of the needed agricultural raw materials. Thus, there continues to be an avoidable increasing capacity underutilisation. One of such important agricultural produce in which Nigeria has potentials is the oil palm. Because of the increased demand for palm oil resulting from an increase in population and income growth, relative to the low productivity of the oil palm sector, Nigeria has become a net importer of palm oil (Olagunju, 2008).

Therefore, there is a critical need for the use and application of improved technology in Nigeria's agriculture sector. Such technology will have to relate not only to production, but also to processing, storage and marketing. With the introduction of such technologies, output in the sector can be increased, and farmers' income improved especially through the marketing of value-added output. This is encapsulated in the third component of the Fadama III as stated in the Project Implementation Manual Volume I (PIM 1) - 'transfer and adoption of technology to expand productivity, improve value-added, and conserve land quality'.

This study therefore assessed the effect of Fadama III technology adoption on the welfare ofpalm oil processors in Osun State. The specific objectives were to:

i. Identify the technologies used by palm oil processors in Osun state before and after the Fadama III project

ii. Determine the rate of adoption of Fadama III palm oil processing technology

iii. Assess the determinants of adoption of Fadama III palm oil processing technology, and

iv. Assess the effects of the adoption on the processors' welfare

This study is important because research had established that adoption of improved technologies and improved crop and livestock varieties reduced poverty incidence and improved livelihood of farmers. Also, the impact on the lives of resource poor farmers is believed to be the most functional benefit of agricultural technologies, policies and programmes and also the preoccupation of the stakeholders (Collinson and Tollens, 1994).

Osun State identified the Fadama III Project as being in support of the State's 6 point integrated agenda for economic development and the State emerged the second best in Nigeria and the best in Southwest in the FADAMA agricultural project. The state has also won community award for best practices by the Federal Government due to its prompt payment of counterpart fund (Osun Ministry of Agriculture and Food Security, 2013)

LITERATURE REVIEW

Since the much publicised achievement of the Asian Green Revolution as a result of improved agricultural technology adoption, and the replication of that effort in developing countries, several studies have focused on assessing the determinants of adoption and intensity of adoption. More recently, the attention has shifted to assessing the impact of adoption of these high yield increasing technologies on poverty and welfare (Simtowe *et al.* 2012, Awotide *et al.*, 2011; Dontsop-Nguezet *et al*., 2011; Nkonya *et al.*, 2008, and Mendola, 2007).

Dontsop-Nguezet *et al.* (2011) examined the impact of the adoption of New Rice for Africa varieties (NERICAs) on income and poverty among Nigerian rice farming households. They used instrumental variables estimators to estimate the Local Average Treatment Effect (LATE) of adopting NERICA on income and poverty reduction, using the cross-sectional data of 481 farmers from the upland, lowland and irrigated rice ecologies. Their empirical results suggested that adoption of NERICA varieties helped raise household per capita expenditure and income by averages of 49.1% and46.0% respectively, thereby reducing the probability of adoptive households falling below the poverty line.

Awotide *et al.* (2012a), also examined the impact of improved rice varieties adoption on rice productivity and farming households' welfare in Nigeria using a cross sectional data of 481 rice farmers drawn from three states to represent the major rice producing ecologies (Irrigated, upland and lowland) in Nigeria. Specifically, the LATE, which uses the system of instrumental variable method was adopted to assess the impact of improved rice varieties adoption on rice productivity and total household expenditure (Proxy for welfare). The results showed a significant positive impact on rice productivity (358.89kg/ha) and total households' expenditure (₦32,890.82). They suggested that adoption of improved rice varieties significantly generate an

improvement in farming household living standard and recommended that efforts should be intensified to ensure that farmers have access to adequate quality improved rice seed at the right time.

Kajisa *et al.* (1997) assessed the factors causing stagnation in the Nigerian Oil palm industry. They adduced that several technological and environmental factors have contributed to the stagnation of the oil palm sector in Nigeria. Oni and Olaniran (2008) analysed the poverty status of Fadama II and Non Fadama II beneficiaries in rural Oyo State, Nigeria and found that being a beneficiary reduces the probability of being poor. In that study, it was concluded that Fadama II project positively impacted on the lives of the beneficiaries and that it will invariably empower the beneficiaries financially above that of non-beneficiaries

Akinlade (2012) investigated the impact of Fadama II on income inequality of rural households in Nigeria. The result showed that across the three agro-ecological zones, annual per capita expenditure increased by 13.8%, 17.1% and 29.1% for Humid Forest (HF), Moist Savannah (MS) and Dry Savannah (DS) zones, respectively with Taraba state having the highest change in mean income of 28% while the least is Oyo state (3.2%). Fadama II was income inequality (IE) decreasing nationwide (21.2%) with female Fadama Beneficiaries (FB) having the highest reduction of 27.2% compared with male counterparts of 14.1%.

METHODOLOGY

Nature of data and sampling procedure

The study focused on palm oil processing households in the 20 LGAs of Fadama III intervention in Osun state. Data was collected using multistage sampling procedure. Four major Palm oil processing local governments were purposively selected (3 are Fadama III participants while 1 is non-Fadama III participant).The 3 participating LGAs were Iwo, Irewole and Ede North while the non-participating LGA was Ayedire. Copies of questionnaire were distributed to palm oil processing households who were: (i) Fadama III project participants (46 respondents) (ii) Those who lived in Fadama III project communities but were not Fadama III participants but with the same Socioeconomic and biophysical characteristics (35 respondents) (iii) Those who lived outside Fadama III project communities (21 respondents). Data collected include household composition and size, major components of household income and expenditure.

Analytical Techniques

Determinants of adoption **-** Logistic regression model was used to assess the factors that determine the processors' adoption of Fadama III palm oil processing technology. The justification for using logit is its simplicity of calculation and that its probability lies between 0 and 1. Moreover, its probability approaches zero at a slower rate as the value of explanatory variable gets smaller and smaller, and the probability approaches 1 at a slower and slower rate as the value of the explanatory variable gets larger and larger (Gujarati, 1995).

Hosmer and Lemeshew (1989) pointed out that the logistic distribution (logit) has got advantage over others in the analysis of dichotomous outcome variable in that it is an extremely flexible and easily used model from mathematical point of view and results in a meaningful interpretation. The parameter estimates of the model are asymptotically consistent and efficient. The binary logistic model does not make the assumption of linearity between dependent and independent variables and does not assume homoscedasticity. Another advantage of using the logit model is that it does not require normally distributed variables and above all, the logit model is relatively easy to compute and interprete. Hence, the logistic model is selected for this study. The probability that a palm oil processor will adopt Fadama III technology was postulated as a function of some socioeconomic and demographic characteristics. Therefore, the cumulative logistic probability model is econometrically specified as

$$Pi = F(Zi) = F\left(\gamma + \sum \lambda i Xi\right) = \frac{1}{1 + e^{-zi}}$$

Where

Pi = the probability that a palm oil processor adopts Fadama III given Xi;

Xi = Set of farmers characteristics like age, household size, years of education, access to credit

γ and λ = parameters to be estimated

Ai = adoption variable which is defined as 0 if a palm oil processor is a non-adopter of

Fadama III processing technology; 1 if a palm oil processor is an adopter.

Effects of Adoption on Farmers' Welfare (Econometric framework for Impact Assessment) **-** According to Awotide *et al.* (2012a) and Akinlade (2012), the most accepted method to address evaluation problems is to use an experimental approach to construct an estimate of the counterfactual situation by randomly assigning households to treatment (beneficiary) and control (non-beneficiary) groups. Random assignment assures that both groups are statistically similar (that is, drawn from the same distribution) in both observable and unobservable characteristics, thus avoiding program placement and self-selection biases. Such an approach is not feasible in this study, since program placement and participation decisions were already made prior to design of this study, and are unlikely to have been random.

The notion of random assignment also conflicts with the nature of this CDD program, in which communities and households make their own decisions about whether to participate and what activities they will pursue; thus limiting the ability to use this approach even from the outset. One of the most commonly used quasi-experimental methods was used-Propensity Score Matching (PSM). The sample collected was matched using PSM; the aim of PSM is to find the comparison group from a sample of non-participants that is closest to the sample of program participants so as to get the impact of the project on the beneficiaries (Nkoya *et al.*, 2008). Matched difference-in-differences (matched DD) is one example of combining methods. Simple PSM cannot account for unobserved characteristics that might explain why a group chooses to enroll in a program and that might also affect outcomes.

By contrast, matching combined with difference-in-differences at least takes care of any unobserved characteristics that are constant across time between the two groups. It is implemented as follows:

i. First, perform matching based on observed baseline characteristics
ii. Second, apply the difference-in-differences method to estimate a counterfactual for the change in outcomes in each subgroup of matched units.
iii. Finally, average out those double differences across matched subgroups. (Gertler et al., 2011).

Explicit exploration of Double Difference Estimator is presented below:

$$DD = (Yp_1 - Yp_0) - (Ynp_1 - Ynp_0) \quad (3)$$

Where Yp_1 = outcome (for example, income) of beneficiaries after the project started;

Yp_0 = outcome of beneficiaries before the project started;

Ynp_1 = outcome of non-beneficiaries after the project started; and

Ynp_0 = outcome of non-beneficiaries before the project started.

Counterfactual estimation **-** Since the match would have been deemed of good quality, the matched sample was then used to compute the Average Treatment Effect for the treated (impact). It is estimated as follows:

$$ATT = E(Y_1|p = 1) - E(Y_0|p = 1)$$

Where ATT = average impact of treatment on the treated;

$E(Y_1|p = 1)$ is the observed outcome of the treated that is, the expected income earned by project beneficiaries while participating in the project

p = participation in the project (p = 1 if participated in the project, p = 0 if did not participate in the project);

Y_1 = outcome (for example, household per capitaexpenditure) of the project beneficiary after participation in project;

Y_0 = outcome (per capita expenditure) of the same beneficiary if he or she had not participated in the project.

Descriptive statistics

Level of income of Fadama III technology adopters and non-adopters and other socio economic characteristics were analysed using descriptive statistics; frequency distribution and percentage.

RESULTS AND DISCUSSION

Socioeconomic characteristics

The 102 respondents were females. This shows that the palm oil processing occupation

is predominantly associated with the female gender in Osun state.

Table 1 shows the socioeconomic characteristics of respondents. The results show that 68.7% of the respondents were 50 years of age and below and the mean age was 49+6.4 years. This age category constitutes 60.9% of Fadama III beneficiaries, 80% of non-beneficiaries in participating LGAs and 57.1% of non-beneficiaries in non-participating LGAs. This implies that the respondents in the area are still in their active ages. Also, results of marital status show that 71.6% of the respondents were married, 1.0% divorced and27.4% widowed. This implies that majority of the processors were married.

Household size is a measure of the human capital that can be supplied by individual household. The mean household size was 5.5+1.5. This implies that respondents had household labour to assist in their processing activities. Educational level measures individual's ability to read and/or write. Also, results show that 23.9% of the beneficiaries had formal education up to secondary school and 4.3% had tertiary education, while none of the non-beneficiaries in participating LGAs and non-beneficiaries in non-participating LGAs had formal education up to secondary school. It is shown from the table that level of formal education is likely to be a pull factor in technology adoption under Fadama III programme.

All the respondents were palm oil processors (primary occupation) but had different secondary occupations. From Table 1, the secondary occupations include trading, processing of other produce such as cassava, and crop farming. Majority of the respondents (60.8%) were involved in trading of one commodity or the other such as foodstuffs and fruits. Trading was the most popular secondary occupation across the categories of the respondents.

Table 1: Distribution of respondents by their socioeconomic characteristics

Variable	Ben (n=46)		NBPL (n=35)		NBNPL (n=21)		Total (n=102)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Age (years)								
<35	0	0.0	2	5.7	0	0.0	2	2.0
35 - 50	28	60.9	26	74.3	12	57.1	66	66.7
51 - 65	18	39.1	7	20.0	9	42.9	34	33.3
Mean ±SD	49.7(±4.1)		47.8 (±9.2)		50.1(±4.9)		49.2(±6.4)	
Marital status								
Married	33	71.7	28	80	12	57.1	73	71.6
Divorced	1	2.2	0	0	0	0.0	1	1.0
Widowed	12	26.1	7	20	9	42.9	28	27.4
Household size								
3-4	8	17.4	7	20.0	12	57.1	27	26.5
5-6	16	34.8	20	57.1	6	28.6	42	41.2
>6	22	47.4	8	22.9	3	14.3	33	32.3
Mean ±SD	6.3(±1.4)		5.8(±1.8)		4.5(±1.2)		5.5(±1.5)	
Educational level								
No formal	16	34.8	28	80.0	18	85.7	62	60.8
education	8	17.4	0	0.0	0	0.0	8	7.8
Adult literacy	9	19.6	7	20.0	3	14.3	19	18.6
Primary school	11	23.9	0	0.0	0	0.0	11	10.8
Secondary	2	4.3	0	0.0	0	0.0	2	2.0
school								
Post-secondary								
school								
Secondary occupation								
Trading	29	63.0	24	68.6	9	42.9	62	60.8
Processing	0	0.0	9	25.7	12	57.1	21	20.6
(other produce)	17	37.0	2	5.7	0	0.0	19	18.6
Farming								

Source: Field survey, 2015

Note: Ben = Fadama Beneficiaries
NBPL = Non-Beneficiaries in participating Local Governments
NBPNL = Non-Beneficiaries in non-participating Local Governments

Technologies used by Palm oil processors and rate of technology adoption

Technologies used by palm oil processors before and after the introduction of the Fadama III programme were identified with the adoption rate. The 3 technologies identified were: leg, hydraulic press/digester with processing pit and hydraulic press/digester without processing pit. Table 3 shows the distribution of processors usingdifferent technologies before and after the programme, as well as the rate of adoption. That is, the transition before and after the project for beneficiaries, non-beneficiaries in participating LGAs and non-beneficiaries in non-participating LGAs respectively.

Rate of technology adoption among beneficiaries

All (65%) of the respondents who were beneficiaries transited from leg to other technologies after the project, that is, 100% adoption rate (among those who used legs for processing). Also, before the Fadama III project, none of them was using hydraulic press without processing pit but after the project, 67% of the respondents were using this technology; which according to them reduces fatigue a great deal.

Rate of technology adoption among non-beneficiaries in Fadama III LGAs

For non-beneficiaries in participating LGAs, all the respondents using leg (14%) also transited to other technologies (Hydraulic press with processing pit); this may be as a result of spill-over effect of Fadama intervention. However, none of them was using the hydraulic press without processing pit both before and after the project.

Rate of technology adoption among non-beneficiaries outside Fadama III LGAs

For those outside participating LGAs, the transition rate from leg was just 10%. Also, there was no transition to hydraulic press without processing pit.

It can then be implied that the rate of improved technology usage increases with Fadama III adoption.

Table 2: Distribution of respondents by rate of technology adoption

Technology	Ben (n=46)		NBPL (n=35)		NBNPL (n=21)		Total (n=102)	
	Freq	%	Freq	%	Freq	%	Freq	%
Leg								
Before Fadama III	30	65	5	14	5	24	**40**	**39**
After Fadama III	0	0	0	0	3	14	**3**	**3**
Hydraulic press with processing pit								
Before Fadama III	16	35	30	86	16	76	**62**	**61**
After Fadama III	15	33	35	100	18	86	**68**	**67**
Hydraulic press without processing pit								
Before Fadama III	0	0	0	0	0	0	**0**	**0**
After Fadama III	31	67	0	0	0	0	**31**	**30**

Source: Field survey, 2015

Mean income before and after Fadama III

Table 3 shows the mean/average income of respondents before and after Fadama III programme. Results show that Fadama III beneficiaries experienced the highest increase of 25% in their income compared to the 7% and 4% increase experienced by the non-beneficiaries in Fadama III LGAs and those in non-participating LGA respectively. This could be related to the rate of technology adoption by each category of respondents. The Fadama III beneficiaries who had the highest rate of technology adoption also had the highest increase in income.

Table 3: Mean Income of respondents before and after Fadama III

Variable	Beneficiaries	Non-beneficiaries in participating LGAs	Non-beneficiaries in non-participating LGAs
Mean Income before Fadama III (₦)	149,771.70	176,428.60	64,714.29
Mean Income after Fadama III (₦)	187,565.20	188,685.70	67,571.43
Percentage Change	**+25.23%**	**+6.95%**	**+4.41%**

Source: Data Analysis, 2015

Determinants of adoption of Fadama III palm oil processing technology

The factors that influenced adoption of the Fadama III palm oil processing technologies were examined using the logistic regression method. The results from the logit model are presented in Table 4. The marginal effects were also calculated as the partial derivatives of the non-linear probability function, evaluated at each variable sample mean (Greene, 2003). The decision to adopt the Fadama III palm oil processing technology was significantly influenced by age, years of formal education, and access to credit.

Age significantly increases the probability of adoption at 5%. This could be attributed to the fact that the average age of the respondents was 49 years (even though they are still in their active years, they are growing older for the stress of the traditional techniques) which could influence adoption. Also, years of formal education increase the probability of adoption significantly at 1%; the more educated a respondent is, the higher the chances of adoption. Meanwhile, access to credit significantly influences probability of adoption negatively; that is, the more the processors had access to credit, the lower the probability of adoption. This could be because a person who has no access to credit will tend to look for other ways of welfare improvement in income and hence more open to adoption.

Table 4: Determinants of adoption of Fadama III project Adoption

Variables	Coefficient	Z-value	P>|Z|	Marginal Effect
Age	1.176306 (0.5652032)	2.08	0.037**	2.284084
Years of education	0.2257172 (0.0811165)	2.78	0.005*	0.3847026
Household size	0.1273859 (0.1558027)	0.82	0.414	0.4327535
Credit access	-1.224142 (0.5930359)	-2.06	0.039**	-0.0159412

Source: Data analysis, 2015
* - Significant at 1%;
** - Significant at 5%

Effect of Adoption of Fadama III palm oil processing technology on welfare

Descriptive analysis of the impact of adoption of Fadama III oil palm processing technologies **-** Descriptive analysis of the impact of Fadama III palm oil processing technology adoption on per capita expenditure of households of respondents (proxy for welfare) is presented in Table 5.

Results show that Fadama III beneficiaries experienced the highest increase of 58% in their per capita expenditure compared to the 8% and 9% increase experienced by the non-beneficiaries in Fadama III LGAs and those in non-participating LGAs respectively. This result is consistent with related studies on the impact of adoption of agricultural technologies on welfare (Awotide *et al.*, 2012b; Mendola, 2007; Diagne *et al.*, 2007; Javier and Awudu, 2010).

From the analysis, it appears the adopters were better-off than the non-adopters. However, these comparisons did not account for the effects of other characteristics of the farmers that could influence these outcomes. Hence, these observed differences cannot be attributed entirely to the adoption of Fadama III technologies due to the problem of selection bias and non-compliance and thus have a causal interpretation (Imbens and Angrist, 1994).

Table 5: Descriptive analysis of the impact of adoption of oil palm processing technologies

Variable	Beneficiaries	Non-beneficiaries in participating LGAs	Non-beneficiaries in non-participating LGAs
Mean Per Capital Expenditure before Fadama III (₦)	9,230.37	13,250.07	6,198.77
Mean Per Capital Expenditure after Fadama III(₦)	14,573.84	14,335.6	6,726.63
Percentage Change	**+57.89%**	**+8.19%**	**+8.52%**

Source: Data analysis, 2015

4.4.2 Econometric analysis of the impact of adoption of oil palm processing technologies

Results in Table 6 show the ATT after some characteristics of the respondents were matched. It shows that being a Fadama III beneficiary significantly increases expenditure by ₦7,105.37. The matched double-difference results show that the expenditure of beneficiaries increased by ₦4,648.79. The adoption of Fadama III palm oil processing technology exerted a positive and significant impact on household expenditure in the study area.

Table 6: Matched double difference results

Estimation method	Sample	Treated	Controls	Difference	S.E	T-stat
PSM	Unmatched	21,304.34	14,986.78	6,327.56	1,613.25	3.92
	ATT	21,333.33	14,227.96	**7,105.37**	2,623.49	2.71
Matched Double difference	Unmatched	5,343.46	876.39	4,467.06	390.32	11.44
	ATT	5,343.46	694.67	**4,648.79**	495.91	9.37

Source: Data analysis, 2015

CONCLUSIONS AND RECOMMENDATIONS

Based on the empirical evidence emanating from this study, the technology introduced by Fadama III to palm oil processors had high rate of adoption among the beneficiaries. The usage of the improved technology significantly improved the welfare of Fadama III beneficiaries. Therefore, such community driven development projects should be encouraged. Currently, Fadama III with additional financing (AF) is on-going and it covers all LGAs in Osun state; however, it is streamlined to only one crop (Cassava). Since the results from this study show that Fadama III technology adoption had positive effect on the rate of adoption and welfare of palm oil processors, the project should be extended to cover other enterprises. Also, education of the rural populace should be encouraged by creation of more schools and adult learning centres in order to aid adoption of new technologies.

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