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Impact of PYXERA Global Yieldwise Project on Improved Tomato Post-Harvest Loss Management Practices of Farmers' Output, Income and Poverty Status in North-West Zone, Nigeria

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ABSTRACT

The study was conducted to determine the impact of PYXERA Global Yieldwise project improved tomato post-harvest loss management practices on farmers output, income and poverty status in North-West Zone, Nigeria. A multi-stage random selection method was used to choose the study locations, and 540 farmers were administered with structured questionnaire. Data were analyzed using the descriptive, double difference estimates and FGT poverty index. The results showed that the difference in value between the two output differences [₦211,255.8 – ₦128,366.86] was ₦82, 888,94. The poverty incidence of poor farm households in the study area was 95% for the non-adopters, and 61% for the adopters. In addition, the poverty depth among the farm households in the study area was 85% for non–adopters and 36% for adopters. The severity of the poverty index was 79% for non–adopters and 26% for adopters of improved tomato post-harvest loss reduction management practices. This implies that poverty incidence is higher among non-adopting poor than their adopting poor households. The study concluded that the adoption of the improved tomato post-harvest management practices had a positive impact on tomato post-harvest loss reduction, income, and poverty status as revealed in the results of this study, although the extent of tomato post-harvest loss was still high. It was therefore recommended that the tomato post-harvest loss reduction campaign should be sustained to further decrease the losses suffered by tomato farmers especially as the end line for achieving the SDG on food loss and food waste draws closer. All stakeholders in the tomato value chain should address other challenges limiting the adoption of improved tomato production and post-harvest loss reduction such as low extension visits, poor market linkages, and distance to market.

Keywords
Impact, Adoption, Farmers' Output, Income and Poverty Status.

Introduction
According to Price Waterhouse Coopers [1], Nigeria's tomato production was estimated at 2.3 million metric tons per year, and its annual demand is estimated at 2.7million metric tons, leaving a supply deficit of 0.4 million metric tons. PWC [1] further observed that Nigeria loses an average of 45% (1.04 million metric tons) of what is produced annually, due to poor post-harvest management practices. This is staggering and costs the country an avoidable loss of an estimated ₦3.6 billion annually [1] in foreign exchange. Post-harvest food loss is the quantity of harvested produce that does not reach the table of consumers [2]. Tomato post-harvest loss is a major constraint to consistent food supply, farmers' incomes, and poverty alleviation. The problem can be resolved using improved post-harvest management practices [3]. The value of proper post-harvest crop management comes in the form of prevention of food losses, improvement of nutrition, and increased monetary value to agricultural produce [4]. For tomatoes, improved post-harvest management practices start at harvest and include harvest timing, pre-cooling, sorting, grading, washing, use of proper packaging

such as returnable plastic crates, storage, transportation, and processing [2]. Tomato post-harvest loss also translates to losses of about 45% of the incomes that would have been earned by tomato farmers if all loss-causing factors were eliminated. According to PWC [1], tomato waste and loss constitute a large and increasingly urgent problem and are particularly acute in developing countries where food loss reduces income by at least 15% for 470 million smallholder farmers.

The North-West zone accounts for the largest proportion of the annual total production of tomatoes in Nigeria. According to a report by the Growth and Employment in State Project-4, the annual average production of the crop in this Zone is estimated to be 1.62 metric tons [5], which is 60% of the total national annual production of 2.3 million metric tons [1]. The implication of this is that the Zone may have the highest number of smallholder tomato farmers who are at the receiving end of the annual post-harvest loss and therefore income losses. According to the United Nations Food and Agricultural Organization (FAO), eliminating or reducing the annual tomato post-harvest loss translates to increased incomes and poverty alleviation for farmers [6]. This would be a very important starting point for agricultural development intervention aimed at poverty alleviation for smallholder farmers in Nigeria.

Among several interventions focused on tomato, post-harvest loss reduction was the Yieldwise project, an initiative of the Rockefeller Foundation that was implemented by PYXERA Global. It had the goal of reducing tomato post-harvest losses by 50% and increasing smallholder farmers' incomes by the same margin. Intervention programs/projects are intended to improve productivity, income and reduce poverty incidence among beneficiaries. The Yieldwise project implemented by PYXERA Global has such objectives too. Hence, the need to determine the impact of adopting improved tomato post-harvest loss management practices, as promoted by the programme, on farmers' output, income, and poverty status in North-West Zone of Nigeria.

Methodology

Study Area

The study was conducted in the North-West geopolitical zone of Nigeria, located between latitudes 9^o and 14^{o}N, and longitudes 7^o and 6^{o}E. It occupies an area of 216,065Km^2 and consists of Sahel, Sudan, and Savannah agro-ecological zones with a mono-modal average annual rainfall of between 600mm to 1200mm that is distributed between April and October yearly and characterized by a short but regular annual drought spell. The mean annual temperature for the area ranges between 17^{o}C and 32^{o}C, which peaks at an average of 42^{o}C between April and May. The states in this Zone include Kano, Katsina, Jigawa, Kaduna, Zamfara, Kebbi, and Sokoto. According to the National Bureau of Statistics [7], the Zone has a projected population of 48,942,307 for 2016 at a growth rate of 3.2%, which is projected to be 55,514,090 in 2021.

Research Design

The study assessed the impact of the Rockefeller Foundation's Yieldwise Project implemented by PYXERA Global from January 2016 to May 2019 in three North-West States of Nigeria, which include Kano, Katsina, and Jigawa States. The project, which has a goal of reducing tomato post-harvest loss by 50% and increasing the income of farmers, was targeted at smallholder tomato farmers [8,9]. The Yieldwise Project conducted a baseline study in 2016 to understand and benchmark the situation of smallholder tomato farmers before the implementation of project activities. The baseline survey assessed the socio-economic characteristics of farmers, the quantities of post-harvest losses, and their level of adoption of tomato post-harvest loss reducing technologies, access to market, loans/credit, and incomes. Farmers that participated in the project's baseline survey were grouped into Treatment group, which include farmers that are residing and participating in the Yieldwise project, and Control group which consist of tomato farmers that were not residing in project communities and are not receiving the project interventions. This study assessed the post-intervention impact of the Yieldwise project on smallholder tomato farmers around three main indicators, which are post-harvest loss reduction, income, and poverty status of farmers. The survey data and contacts of farmers that participated in the Yieldwise projects baseline survey were obtained from PYXERA Global. The general research design was qualitative. It is tended more to a correlational and descriptive design.

Sampling Procedure and Sample Size

A multi-stage sampling procedure was used by the Yieldwise project in selecting the States, Local Government Areas (LGA), and communities for selecting the locations for the intervention. A list of all major tomato-producing states in the Northwest was drawn based on the number of farmers and proportion of tomatoes produced, and their proximity to a tomato-processing factory. Three states were selected which include Kano, Jigawa, and Katsina. From each of these States a list of all tomato producing LGAs was drawn, and the final selection was based on a pre-determined number of LGAs, the number of tomato farmers present, and the level of production. Nine LGAs were selected in Kano State, five in Jigawa State, and four in Katsina State. From the sample framework, a proportionate sample size of 5% was randomly drawn from the Treatment (Intervention) group, and from the Control (Non-intervention) group. This was for the baseline survey conducted by the Yieldwise project.

The list and contacts of the farmers that participated in the baseline survey was sourced directly from PYXERA Global for the endline survey which was conducted in September 2021. The confidence level for this study is 95% {z=1.96}.

Method of Data Collection

The primary data for the impact study was collected through a field survey between September and October 2021 using a pre-tested structured questionnaire, which was administered by experienced extension officers who speak English and Hausa languages fluently. The baseline data used for this study was collected through a field survey in 2016 by the Yieldwise project staff.

Analytical Techniques

Data for this study were analyzed using the following statistics methods: Descriptive statistics, gross margin analysis, logit regression model, Difference-in-Difference (DiD) model, and Foster-Greer-Thorbecke (FGT) poverty indices.

Inferential Statistics

The mathematical equation for the DiD is stated as follows:

$Y_{it} = \beta_0 + \beta_1 post_{it} + \beta_2 T_{it} + y.post_{it}.T_{it} + \beta_3 x_{it1} + \ldots\ldots + \beta_k x_{itk} + U_{it}$ ……………………………...……. (1)

Where:

$Post_{it}$ = (Dummy variable) = 1

T_{it} = (Dummy variable) = 1

Y = Parameter of interest (average treatment effect)

Foster-Greer-Thorbecke poverty indices

$FGT_2 (P_x)$ is expressed as follows:

$$P_x = \frac{1}{N}\sum_{i=1}^{a}\frac{[z-Y_1]^a}{z} \quad \text{-- (2)}$$

Where:

N is the population of interest,

Z is the poverty line,

N is the number of farmers that are below the poverty line,

Y_1 is the income of the farmer (or his household), and

X is the degree of concern for the depth poverty, and takes the value of 0,1, and 2, representing the incidence of poverty, the poverty gap, and the severity of poverty which are derived as follows:

$$P_x = \frac{1}{N}\sum_{i=1}^{a}\frac{[z-Y_1]^0}{z} \quad \text{--(3)}$$

$$P_x = \frac{1}{N}\sum_{i=1}^{a}\frac{[z-Y_1]^1}{z} \quad \text{--(4)}$$

$$P_x = \frac{1}{N}\sum_{i=1}^{a}\frac{[z-Y_1]^2}{z} \quad \text{--(5)}$$

Model for Income Estimation

The income data collected from the survey was used to calculate the Gini index for each farmer, using the following formula:

$GC = [2x \, Cov\,(Y_1, F(Y))/Y]$

Where:

GC = Gini index of income inequality

Y_1 = mean income in the quintile

F(Y) = cumulative distribution of income

Y = mean income for all the farmers surveyed

Results and Discussion

Impact of Adoption of Tomato Post-Harvest Management Practices on Output of Tomato Farmers

The double difference estimates of the impact of adoption of tomato post-harvest loss reduction on output of farmers are presented in Table 1. The mean pre-intervention, tomato loss of adopters in period one (T1) was 71.39 Kg, and it was 50.75 Kg for non-adopters. Therefore, the difference in mean tomato post-harvest loss between adopters and non-adopters in period one (T1) was 20.64 Kg. In period two (T2), that is the post-intervention period, the mean tomato loss for adopters was 36.49 Kg, and for non-adopters was 40.79 Kg, and the mean difference in tomato loss between adopters and non-adopters in period two (T2) was -4.3 Kg. The mean difference in tomato loss between periods (T1 and T2), between adopters and non-adopters was therefore 24.94 Kg. The double difference estimate indicates that tomato loss reduction between adopters and non-adopters, and before and after the intervention was 24.94 Kg. The implication is that adoption had a positive impact on adopters because it reduced the number of tomatoes lost at post-harvest. It, therefore, resulted in a net gain for the farmers.

Table 1: Double difference estimates of the impact of the adoption of tomato post-harvest loss management practices on the quantity of tomato loss to farmers.

Group	Quantity of tomato loss		
	Before (Kg)	After (Kg)	Difference between Periods
Adopters	71.39	36.49	-34.9
Non-Adopters	50.75	40.79	-9.96
Difference between Groups	20.64	-4.3	-24.94

Double Difference Estimates of Regression Analysis on the Impact of the Adoption of Improved Tomato Post-Harvest Loss Management Practices on Farmer's Tomato Post-Harvest Loss

The estimates of double difference from regression analysis of the impact of adoption on loss reduction are presented in Table 2. It was found that the interaction term between Treatment and Period (T_i*P_t) was positive and statistically significant at a 5% level of probability. This implies that adoption had a positive and significant influence on post-harvest loss reduction among tomato farmers. It also indicated that of the four (4) variables included in the regression model, age (0.0114) and household size (0.0162) had positive coefficients but are not statistically significantly related with output. Education had a negative coefficient and is statistically significant at 1% level of probability, while farmers experience had a negative coefficient and is not significantly related with output. The coefficient of the interaction term (*Ti*Pt*) between the mean annual post-harvest tomato loss of both adopters and non-adopters had a negative value and is statistically significant. The negative value notwithstanding is just an indication of loss. This implies that adoption had a positive and significant influence on post-harvest loss reduction among tomato farmers. This result is consistent with the findings of Folorunsho [10] who reported that Fadama III project beneficiaries were better off than their non-beneficiary counterparts in terms of income and productivity. The null hypothesis, which states that the adoption of tomato post-harvest management practices, has no significant effect on tomato post-harvest loss reduction, income, and poverty status of farmers is therefore rejected while the alternative is accepted.

Table 2: Result of double difference estimates from regression analysis of the impact of the adoption of improved tomato post-harvest management practices on tomato post –harvest loss.

Variable	Coefficients	Standard Error	T-Value
Constant	1.4050	0.5744	2.446
P_t	-0.5707***	0.1077	-5.297
T_i	-0.1276	0.0967	-1.319
$P_t * T_i$	0.7562**	0.3552	2.129
Age	0.0114	0.3781	0.030
Household size	0.0162	0.1195	0.135
Education	-0.1868***	0.0623	-2.999
Experience	-0.0010	0.0041	-0.254
F-value	8.690		
Prob>F	0.0000		
R-squared	0.548		
Adj R-squared	0.485		

*Note: ***, ** and * significant at 1%, 5% and 10% levels of significance*
Note: Quantity of tomato post-harvest loss was used as a proxy for tomato post-harvest loss
*Note: Pt (period, before and after), Ti =treatment (Adoption), Pt * Ti (Interactions)*

Impact of adoption of tomato post-harvest management practices on incomes of tomato farmers

The double difference estimates of the impact of adoption on the net farm income of adopters and non-adopters are presented in Table 3. The mean income difference of the adopters was ₦165,400.19 and ₦376,655.99 before and after extension contact. The difference between after and before values is ₦211,255.8, which is the first single difference. The mean income difference of the non-adopters was ₦270,562.14 and ₦142,195.28 before and after extension contact. The difference between before and after values is –₦128,366.86, which is the second single difference. The double difference, that is, the difference between the two output differences [₦211,255.8 – ₦128,366.86] is ₦82, 888.94. This indicates that the double difference estimates of the net farm income of adopters and non-adopters of tomato post-harvest loss management practices had a positive value. The implication is that adoption had a positive impact on the adopter's net farm income. This agrees with findings by Folorunso [10] on the impact of SACCOS credit on the crop output of beneficiaries, and that of Ibrahim [11] whose work on the impact of the USAID MARKETS maize project indicated an increase in income and productivity of beneficiaries in Kaduna State.

Table 3: Double difference estimates of the impact of the adoption of improved tomato post-harvest management practices on income of farmers.

Group	Total Annual Income		Difference between
	Before (₦)	After (₦)	Periods (₦)
Adopters	165400.19	376655.99	211255.8
Non-Adopters	270562.14	142195.28	-128366.86
Difference between Groups	-105161.95	234460.71	82888.94

The estimates of double difference from regression analysis of the impact of adoption on the income of adopters are presented in Table 4. It was found that the interaction term (T_i*P_t) had a positive coefficient and was statistically significant at a 5% level of significance. It indicates that of the four variables included in the regression model, age and education had negative coefficients and were statistically significant at 1% and 5% levels of probability respectively. Household size and experience had a positive coefficient but were not statistically significant with income.

Table 4: Result of double difference estimates from regression analysis of the impact of the adoption of improved tomato post-harvest management practices on incomes.

Variable	Coefficients	Standard Error	T-Value
Constant	5.9077	0.8276	7.140
P_t	-1.4511***	0.1542	-9.410
T_i	-0.1217	0.1381	-0.880
$P_t * T_i$	1.0266***	0.1946	5.280
Age	-0.4729***	0.5447	-0.870
Household size	0.0428	0.1724	0.250
Education	-0.2114**	0.0898	-2.350
Experience	0.0011	0.0059	0.180
F-value	17.87		
Prob>F	0.0000		
R-squared	0.591		
Adj R-squared	0.511		

*Note: ** and * significant at 1% and 5% levels of significance*

Impact of adoption of tomato post-harvest management practices on the poverty level of tomato farmers

The result in Table 5 shows the estimation of the poverty line of poor and non-poor households, and the impact of the adoption of the improved tomato post-harvest management practices on the poverty status of adopting households in the study area. The farm household's poverty status among the adopters and non-adopters was analyzed using the three indicators of poverty: the prevalence of poverty (Po), poverty depth (P1), and the severity of poverty (P2). Prevalence of poverty indicates the percentage of the households falling below the poverty line; poverty depth shows the amount by which the poor fall short of the poverty line and severity of poverty is the sum of the square of poverty depth divided by the number of poor households in the sample. As shown in Table 5, the poverty incidence for the non-adopters and adopters was respectively 0.954 representing 95% and 0.613 representing 61% of the farm households in the study area were poor, while 0.046 and 0.387 representing 4% and 39% of respective non-adopters and adopters of improved tomato post-harvest loss reduction management practices were non-poor. The poverty depth among the farm households in the study area was 0.850 (85%) and 0.360 (36%) for non–adopters and adapters, respectively. The severity of the poverty index was 0.790 and 0.257 representing 79% and 26% respectively of the non-adopters and adopters of improved tomato post-harvest loss management practices which represent the poorest among the poor farm households who require the attention of policymakers in the distribution of the standard of living indicators, such as health care services, clean water, and income-generating activities [11].

Table 5: Poverty profile and indices among the farmers.

Poverty Profile	Non –Adopters		Adopters	
	Frequency	Percentage	Frequency	Percentage
Poor	515	95.4	331	61.3
Non-poor	25	4.6	209	38.7
Total	**540**	**100**	**540**	**100**
FGT Poverty Indices				
Poverty incidence(headcount)	0.954		0.613	
Poverty depth(gap)	0.850		0.360	
Poverty severity	0.790		0.257	
MPCFI	**₦ 179515.73/ annual**			
Poverty line (2/3*MPCFI)	**₦ 119677.15/ annual**			

MPCFI is the mean per capita farm income

The double difference estimates of the impact of adoption on the poverty status of respondents are presented in Table 6. The per capita annual farm income was used as a proxy for poverty status. It was found that the per capita annual farm income difference of the adopters was ₦32,482.66 and ₦157,167.48 before and after adoption, respectively. The difference between after and before the adoption is ₦124,684.80, which is the first single difference. The per capita annual farm income difference of the non-adopters was ₦30,969.52 and ₦21,757.76 before and after adoption. The difference between after and before values is -₦9,211.77, which is the second single difference. The double difference, that is, the difference between the two mean per capita annual farm income differences [₦124,684.8 - (-₦9211.77)] is ₦133,896.60. It indicates that the double difference estimates of the per capita annual farm income of adopters and non-adopters of the improved tomato post-harvest loss management practices had a positive value. A positive mean double difference in per capita annual farm income value indicates an increase in beneficiaries' per capita annual farm income [11]. The implication is that adoption had a positive impact on the per capita annual farm income of adopters.

Table 6: Double difference estimates of the impact of the adoption of the improved tomato post-harvest management practices on the poverty status of tomato farmers.

Group	Per Capita Annual Farm Income		
	Before (₦)	After (₦)	Difference between Periods
Adopters	32482.66166	157167.4813	124684.8
Non-Adopters	30969.52388	21757.75839	-9211.77
Difference between Groups	1513.137782	135409.723	133896.6

The estimates of double difference from regression analysis of the impact of adoption on the poverty status of farmers, which used per capita annual farm income as a proxy for poverty status, are presented in Table 7. It was found that the interaction term (T_i*P_t) had a negative coefficient and was statistically significant at a 10% level. It indicates that, of the four variables included in the regression model, household size was positively related and statistically significant with income at a 1% level, while education was negatively related and statistically significant with income at a 5% level. The implication is that adoption has a significant influence on the per capita annual farm income of the farmers. The per capita annual farm income of adopters is significantly different from the per capita farm income of the non-adopters in the study area. This result is consistent with the findings of Issa [12] and Dutse [13] who found that adopters of innovations were better off than their non-adopted counterparts in terms of farm income and productivity.

Table 7: Result of double difference estimates from regression analysis of the impact of the adoption of tomato post-harvest management practices on the poverty status of a tomato farmer.

Variable	Coefficients	Standard Error	T-Value
Constant	-0.2285	0.0494	-4.623
P_t	0.0239	0.0323	0.740
T_i	-0.3400***	0.0362	-9.394
$P_t * T_i$	-0.7650*	0.4561	-1.677
Age	0.0006	0.0011	0.581
Household size	0.0164***	0.0021	7.905
Education	-0.0026**	0.0012	-2.204
Experience	-0.0004	0.0014	-0.267
F-value	46.74		
Prob>F	0.0000		
R-squared	0.443		
Adj R-squared	0.402		

*Note: *** and ** significant at 1%, 5% and 10% levels of significance*

The estimates of double difference from regression analysis of the impact of adoption on the poverty status of farmers, which used per capita annual farm income as a proxy for poverty status, are presented in Table 8. It was found that the interaction term (T_i*P_t) had a negative coefficient and was statistically significant at a 10% level. It indicates that, of the four variables included in the regression model, household size was positively related and statistically significant with income at a 1% level, while education was negatively related and statistically significant with income at a 5% level. The implication is that adoption has a significant influence on the per capita annual farm income of the farmers. The per capita annual farm income of adopters is significantly different from the per capita farm income of the non-adopters in the study area. This result is consistent with that of Issa [12] and Dutse [13] who found that adopters of innovations were better off than their non-adopted counterparts in terms of farm income and productivity.

Table 8: Result of double difference estimates from regression analysis of the impact of the adoption of tomato post-harvest management practices on the poverty status of a tomato farmer.

Variable	Coefficients	Standard Error	T-Value
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P_t	0.0239	0.0323	0.740
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Age	0.0006	0.0011	0.581
Household size	0.0164***	0.0021	7.905
Education	-0.0026**	0.0012	-2.204
Experience	-0.0004	0.0014	-0.267
F-value	46.74		
Prob>F	0.0000		
R-squared	0.443		
Adj R-squared	0.402		

*Note: *** and ** significant at 1%, 5% and 10% levels of significance*

Conclusion and Recommendations

Adoption of the PYXERA Global Yieldwise project improved tomato post-harvest loss management practices resulted in a net tomato loss reduction of 24.9 4Kg. This is positive but could be better with increase in the level of adoption. It is against this backdrop that the study makes the following recommendations: (i) Policy makers and agricultural development programme practitioners should promote programmes and enact policies that promote the development, dissemination, and adoption of agricultural technologies, particularly in rural farming communities to reduce post-harvest loss, increase income, and reduce poverty incidence among farmers. (ii) The PYXERA Global should improve the extension services to farmers to enable wider participation in the project. (iii) Finally, critical factors in the project strategies aimed at reducing post-harvest loss, such as the price of equipment and inputs, should be subsidized and provided to farmers, to ameliorate the constraints leading to loss of tomato crops at post-harvest.

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