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IMPACT OF ADOPTION OF QUALITY PROTEIN MAIZE ON POVERTY STATUS OF RURAL FARMING HOUSEHOLDS IN NORTHWEST, NIGERIA

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ABSTRACT
The study assessed impact of adoption of quality protein maize (QPM) on rural poverty status of households in Northwest, Nigeria. The study collected data from 652 households using descriptive statistics; t-test, poverty decomposition, propensity score matching, average treatment effect, and potential outcome mean to analyze the data. The study found that about 29% - 31% (₦351, 894 - ₦401, 658) of household expenditure goes to the purchase of food. It was equally established that 32% - 37% (₦111, 878 - ₦141, 783) of household's non-food expenditure was on cloth, transport, school fees and school materials. The average per capita expenditure poverty for farmers was ₦90.5 to ₦2863.60 per head per day. For farmers that do not adopt QPM, their current multidimensional poverty was 38% and had they choose to produce QPM, their multidimensional poverty index (MDPI) would be 34.7%. The current expenditure poverty status was 33% and had they choose to produced QPM, their expenditure poverty would be 61%. The study recommended increase in the publicity of QPM through bulletin, guide, and radio jingle in the study area.

Keywords: Adoption, Households, Impact, Maize, Northwest, Poverty.

INTRODUCTION
Poverty is a universal challenge for most African countries. It is not only spreading fast, but also becoming severe in many locations. In response to that, the governments and development partners renewed their interests and re-committed themselves to poverty reduction. However, it appears that there is little or no meaningful progress on global efforts for millennium and sustainable development goals on eradicating extreme poverty and hunger, precisely in Nigeria. Nigeria possesses the greatest development potentials in Africa, given the vastness of her resources and above all her rich human resource endowment. However, regardless of these potentials the country is still among the poorest countries of the world. Recent report has shown that, about 86.9 million of Nigerians are living in extreme poverty (World Bank, 2019). The figures represent nearly 50% of the country's estimated 180 million populations. Regrettably, poverty is widespread, where about (65%) of the poor reside in rural areas and 78% of those likely to be chronically poor are among smallholder farming households (Action Against Hunger, 2019). Poverty is a State or condition where an individual is not able to cater adequately for his/her basic needs of food, clothing and shelter. It is condition an individual is unable to meet social and economic obligations, lacks gainful employment, skills, assets and self-esteem; and has limited access to social and economic infrastructures, such as education, health, potable water, and sanitation; and consequently has limited chance of advancing his/her capabilities (Aminu *et al.*, 2018). Similarly, according to a World Bank Report (2019), the meaning of poverty comprises of hunger, lack of shelter, sickness, illiteracy,

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joblessness, uncertainty, high mortality rate, disease, polluted environment, powerlessness and lack of freedom.

In Nigeria, successive government has approached poverty alleviation in different ways thought the problem can be managed. Yet, despite all efforts, the problem of poverty continues to be visible among the populace. However, it is a common believed that agricultural production remains an important source of livelihood for most people living in rural areas. Therefore, any substantive growth of agriculture and its related industry will be the right direction to poverty alleviation. Consequently, to reduce rural poverty, effort should be focused on improving household agricultural related activities prominently among the farmers via enhancing productivity and adoption of improve varieties (such as QPM) as well as expanding the range of potential agricultural diversification activities of family members using different livelihood strategies. Different maize varieties especially QPM was released to farmers for the past one (1) decade for reducing household malnutrition and reducing poverty among farmers (Yasin *et al.*, 2018). It is on this note that this study attempt to link the adoption of Quality protein maize and poverty alleviation in Northwest Nigeria. Unfortunately, no study attempt provides explanation on how Quality Protein maize was accepted by farmers as well as to link its adoption on reducing rural poverty among farming households (Aminu *et al.*, 2018).

As such, the study was carried out to evaluate impact of adoption of quality protein maize on how it will affect poverty alleviation among the farming households in Northwestern Nigeria. The specific objectives were to: describe the demographic characteristics of farmers; determine the of awareness and adoption level of quality protein maize variety among farmers; determine the poverty status of poverty status of quality protein maize farmers; and determine the impact of adoption of quality protein maize on households' poverty alleviation.

MATERIALS AND METHODS

The Study area

The study area is Northwest, Nigeria. The Northwest zone of Nigeria comprises of 7 States and 181 local government areas. The seven (7) States in the zone are Katsina, Kano, Kebbi, Kaduna, Zamfara, Jigawa and Sokoto. The total land area covered by the zone is 217,591km^2. Kaduna State has the largest land mass with about 46053km^2 constituting 21.2% of the entire land area of the zone. Kano has the least with only 20766 km^2 at 9.5% land mass of the entire zone. The zone lies between longitude 10^0 20'N in Kaduna and 12^0 15'N in Katsina State, with latitude 4^0E in Kebbi State and 9^0 45'E in Jigawa State.

Sampling Techniques and Sample Size

A multi-stage sampling procedure using stair approach was used for the study. The first stair was that five (5) out of seven (7) States selected for the survey based on contribution of maize land area and total maize production in the zone. Total maize land area and maize output from all the seven (7) States in 2018 in the zone was collected and percentage contribution by each State to the total was estimated. The States were ranked from one (1) to seven (7) based on States average percentage contribution in total maize output. Random number was generated for each State in excel. States were sorted in ascending order based on the random number generated for each State. The random numbers for each State were; 0.7453 for Zamfara, 0.7242 for Jigawa, 0.6866 for Kaduna, 0.4259 for Kano, 0.1742 for Katsina, 0.0820 for Kebbi, and 0.0539 for Sokoto. In total, 25 communities, 50 villages and 652 farmers was as the sample size for the study. The detail of the farmers from each State was: Kaduna has 208; 165 for Kano; 112 each for Katsina, Jigawa 119 and Zamfara had 48 (Table 1). It is worthy to note that due to the insecurity situation in Zamfara, the study does not warrant collecting much data from farmers as it is planed initially to collect 120.

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Table 1: Sampling Frame and Size Selection Plan of the Study

State	LGAs	Communities	Sample Frame	Sample Size	QPM	NMZ
Jigawa	3	8	450	119	63	56
Kaduna	5	17	950	208	84	124
Kano	6	18	1100	165	77	88
Katsina	4	13	550	112	72	40
Zamfara	3	4	270	48	29	19
Total	**21**	**60**	**3,320**	**652**	**325**	**327**

Method of Data Collection and Processing

Primary data was the form of data for the study, the data was collected electronically from the farmers using structure questionnaire design, using computer-assisted personal interview (CAPI) with help of tablets and android devices. Enumerators use the device to interview the maize farmers selected from each community, and from each of the local government areas of the selected States. Information on the socio-economic, demographic characteristics, current production practice used inputs, output, farm size, information on farmers' preference of maize features and adoption of quality protein maize; household expenditure and consumption pattern, others are agricultural infrastructure, health; education and other livelihoods pattern were capture. The electronic questionnaire was designed and developed by Microsoft excel 2016 posted to computer-assisted personal interview platform notably Ona server a platform providing cloud storage for computer assisted survey for conversion to extensible markup language (XML) format using a cloud account and downloaded to the devices for enumeration using Open data kit (ODK) collect. The enumerators were train on how the data can be collected and submitted, whereas monitoring of the completed data was done real time, as the data is being collected right on the field each day. In addition, a checklist was use to capture other vital information that might reflect issues relating to the entire community directly from maize farmers during interactive session.

Analytical Techniques

In the composite indexing; the data obtained for poverty have more than one dimensions, and are as well measure with different scales, therefore they need to be reduce for effective assessment of poverty. Therefore, the use of composite index and principal component are essential in this regard. Indexing used in this study include the composite index. It is use to determine some vital indicators for the work, those indices include multidimensional poverty index. Three (3) approaches of generating the indices use are Normalization (standardization) approach, principal component analysis, and Simson indexing approach. The composite index and principal component was used in generating indices for multidimensional poverty index (Majumdar, 2015; and Mohamed *et al*., 2016). The composite indexing is given as:

$$X_z = \sum_j^i \left(\frac{X_{ij} - \text{Min}\{X_{ij}\}}{\text{Max}\{X_{ij}\} - \text{Min}\{X_{ij}\}} \right) \quad \ldots(1)$$

where;
X_z = Multidimensional poverty. Min = minimum value of the ith, max is the maximum value of the ith variable, X_{ij} = observed value x ith at jth individual; Organization for Economic Co-

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operation and Development (OECD, 2008); Andrew & Brendon (2012); Majumdar (2015); and Mohamed *et al.* (2016).

Two different approaches of poverty estimation were tackling in the study. The household expenditure approach and Foster, Greer and Thorbecke Model (FGT2) approach: The FGT model had been previously used by (Alkire *et al.,* 2015). The study employed a mathematical model developed by (Alkire & Foster, 2014), known as the FGT2 model of poverty decomposition and for expenditure poverty. This was adopted to determine the incidence, depth and severity of poverty in the study area. Poverty line calculated based on mean and median of data on composite index generated from multidimensional poverty indicators and for median of household expenditure.

The poverty status of the QPM producing households was determined using FGT2, and MPI index. The indices are classed into five (5) categories destitute, very poor, vulnerable at risk, better off and well to do. Although at some analysis only poor and non-poor are used. Poverty status regarded as the position of the household's 2/3 of mean and median MPI score as the poverty threshold (poverty line) and 2/3 of mean and median expenditure score per head. Generalized form of FGT is express as:

$$P_i = \frac{1}{N}\sum_{i=1}^{x} 1\{y_i > z\} \quad \ldots (2)$$

Square Poverty Gap (Poverty Severity) index

$$P_i = \frac{1}{N}\sum_{i=1}^{x}\left[\frac{G_i}{z}\right]^{\propto} \quad \ldots (3)$$

$$\propto = \geq 0$$

where; N = Sample, z = poverty line, G_i = poverty gap, $\propto$ = Parameters; meaning that the $\propto$ larger the index the more the weight on the position of the poorest.

$$P_{sst} = P_0 P_1{}^{p}\left(1 - \widehat{G}^{p}\right) \quad \ldots (4)$$

P_0 = Headcount index P_1 Poverty gap for the poor only $\widehat{G}^{p}$ = Gini index for the Poverty gaap for the whole population

In the propensity score matching; the causal effect of technology transfer on poverty was determine using the average treatment effect among farmers. The outcome of the propensity score is use to estimate the average treatment effect for each variable the PSM is based on the logit model specified as:

$$Y_i = \ln\left(\frac{P_{ij}}{1-P_{ij}}\right) \quad \ldots(5)$$

$$Y_i = \beta_o + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \beta_4 x_{4ij} + \cdots + e_{ij} \quad \ldots(6)$$

where; the outcome variable is given as:

$$\delta_i = \begin{cases} -x, & x_i < 0 = \text{xA1 = Not Adopted QPM} \\ x, & x_i \geq 1 = \text{xA1 = Adopted QPM} \end{cases} \quad \ldots(7)$$

α_1 = Poverty index or MDPI and Expenditure per head
δ = Adoption (Adopted QPM or Not Adopted QPM
β_1 = Household size (number of people providing unpaid family labour)
β_2= Age of the farmer (years)
β_3 = Group membership (years of membership)
β_4 = Previous season farm income for maize

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β_5 = Total farm size (ha) excluding maize
β_6 = Total farm size (ha) for maize
β_7 = Extension contact (Average number of extension contact per cropping season)
β_8 = Sex
β_9 = Value productivity
β_{10} = Amount of credit access
$\beta_0 - \beta_9 =$ Parameters to be estimated
$e_i =$ disturbance term
$i =$ farm household

Further, the propensity score matching based on nearest neighbours and other matching algorithm was specify as:

$$ATT_1 = \frac{1}{N_T}\left[\sum_{i \epsilon T} Y^t{}_i - \sum_{j \epsilon c(i)} \omega_{ij} Y^c{}_j\right] \quad \ldots (8)$$

where;
ATT_1 = Average treatment effect for the treated for each on poverty, $N_T =$ number of farmers in the treated groups, $C\ (i)$ = Set of controls matched to treated units I, $\omega_{ij} = \frac{1}{N_i{}^c}$ if $j \epsilon c(1)$; 0, otherwise$i =$ ith farm household.

RESULTS AND DISCUSSION

Demographic Description of the Respondents

In this study, total household expenditure and multidimensional poverty index were used to classify households in the study area into five (5) poverty categories. These categories are destitute, very poor, and vulnerable at risk, better-off and well to do. The demographic description of the respondents in the study area is shown in Table . It was found that the average age of household heads among destitute households was 43 years; very poor farming households heads has an average age of 38 years. Table 2 equally shows that, destitute households had the highest average household size with about 11 people per households, while the well-to-do households had the lowest size with about 3 people per households; the mean household size in the study area is 6 people. The national households size was reported by NBS 2020 as 6 for rural and 5 for urban.

Nonetheless, for household dependency ratio, very poor households had the highest dependency ratio of 44.2%, whereas well-to-do households had the lowest dependency ratio of 7.5%. Similarly, the well-to-do households had the highest amount of total food expenses amounting to about ₦1,268,856; the destitute households on the other hand had the lowest amount of total food expenses of ₦282,121 equivalent to ₦25,647.35 per person per year. Although, the total food expenditure for the destitute households is the lowest yet the expenses is about twice above the national poverty line of ₦137,430 per person per year estimated and reported by National Bureau of Statistics (2020). For total non-food expenses, very poor households had the highest number of total households' non-food expenses amounting to about ₦157,926 equivalent to ₦22,560.81 per person per year, while the well-to-do households had the lowest amount of total non-food expenses of ₦123,350 equivalent to ₦41,116.67 per person per year.

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The study also found that destitute households had the highest number of adult female, adult male and youth with 185, 161, and 101, respectively. In all the five poverty categories only those households that their per capital expenditure is above the poverty line of ₦137,430 set by NBS only households that are considered non poor, they include the vulnerable at risk, better off and well to do households were able to cross the line set by government (NBS, 2020).

Table 2: Demographic Description of the Respondents

Demography	**Destitute**	**Very Poor**	**Vulnerable at risk**	**Better-off**	**Well-to-do**
Average Age of household head in years	43.07	38.57	34.47	33.44	31.00
Average household size number of people	11	7	6	3.0	3
Household dependency %	42.3	44.2	43.9	27.2	7.5
Total food expenses per household in naira per annum	282,120.9	468,206.5	796,156.4	658,215.4	1,268,856.3
Total non-food expenses in naira per annum	138,052.7	157,925.7	142,560.5	129,082.0	123,350.0
Total household expenditure in naira per annum	420,173.6	626,132.3	938,716.9	787,297.4	1,392,206.3
Expenditure in naira per head per day	97.1	244.0	415.8	722.0	2073.7
Number of adult female	185	41	7	3	1
Number of adult male	161	41	7	3	
Number of youth	101	52	24	19	7

Source: Field survey, 2020

Education Level of the Respondents by Poverty Status

The study assess the education level of the respondents in the study area and found that destitute household heads had the highest number of households about 64.5 % of them without formal education, while the well-to-do households had the lowest number about 1.3 % without formal education. The Table 3 shows the description of education level of respondents in the study area by their poverty status. This result had some varying outcome with both the national and State-by-State level of education reported by National Bureau of Statistics (NBS, 2020). In some States the values is lower than the State-by-State and national values while in some that value is higher than the national and State-by-State figures.

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Table 3: Education Level of the Respondents by Poverty Status

Education level	Destitute	Very Poor	Vulnerable at risk	Better-off	well-to-do
Number of Household without formal education	64.5	19.4	10.5	1.5	1.3
Number of households with Adult Education	17.7	4.5	0.0	0.4	2.6
Number with Primary education	7.8	8.2	13.2	20.7	1.3
Number with Secondary education	8.5	43.3	44.7	74.9	2.6
Number of household heads with Post-Secondary	1.4	24.6	31.6	2.6	92.3
Total	100	100	100	100	100

Source: Field survey, 2020

Awareness and Adoption of Quality Protein Maize Variety among Farmers

Before adoption is examined, level of awareness was first examined. Since intuitively farmers cannot adopt what they do not know, therefore, knowledge comes first before adoption. On the level of awareness of quality protein maize (QPM) among farmers, Table 4 shows that 21.6 % of the respondents from Jigawa State were not aware of QPM, while 16.6 % were aware. Table 3 shows the details. This shows that respondents in Kaduna had the highest rate of QPM awareness while Zamfara State had the lowest rate of awareness of QPM. Awareness is very important in adoption studies this result varied with the work of Kudi *et al.* (2011) who reported that awareness of new maize variety was about 50% in Kwara, while in this study even Kaduna where IAR and NAERLS reside the awareness level of the QPM is relatively low compared to their findings. Consequently, it will not be out of place if awareness on the benefits of QPM is improved to farmers in the region.

Table 4: Level of awareness of QPM by State

State	Aware		Not aware		Proportion of not aware	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Jigawa	72	16.6	47	21.6	119	39.5
Kaduna	164	37.8	44	20.2	208	21.2
Kano	115	26.5	50	22.9	165	30.3
Katsina	64	14.7	48	22.0	112	42.9
Zamfara	19	4.4	29	13.3	48	60.4
Total	434	100.0	218	100.0	652	33.4

Source: Field survey, 2020

The Adoption Level of QPM Variety among Farmers in Northwest Nigeria

The adoption level between normal and QPM is reported on Table 5 was equally found that from Jigawa 19.4% of the farmers adopt NMZ, from the same State farmers that adopt QPM was 17.1%. Farmers in Kaduna State had highest adoption level of QPM with 37.9% while 25.8 % adopted NMZ. Kano State farmers had QPM adoption level of 26.9 % while 23.7% adopted NMZ.

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Table 5: Adoption Level of QPM Farmers

State	NMZ		QPM		% Adoption of QPM	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Jigawa	63	19.4	56	17.1	119	47
Kaduna	84	25.8	124	37.9	208	59.6
Kano	77	23.7	88	26.9	165	53.3
Katsina	72	22.2	40	12.2	112	35.7
Zamfara	29	8.9	19	5.8	48	13
Total	325	100.0	327	100.0	652	50.2

Source: Field survey, 2020

Multidimensional Poverty Status of Farmers in the Study Area

A useful feature of Lorenz is that, contrasts between subpopulations (or outcome variables) can be computed between two or sets of observation, which is useful for comparison, and visualization. The Figure 1 shows the Lorenz curve for the multidimensional poverty across the States. The gap between poor and non-poor in the curve is not large because the index is a fraction, variability among them is marginal hence the small size. But the numerical indicators like head count, poverty gap, poverty gap square and Gini analytical tool provide distinctive evidence of variability between poor and non-poor households across the States and between farmers that adopted QPM and those that do not adopted QPM in the region.

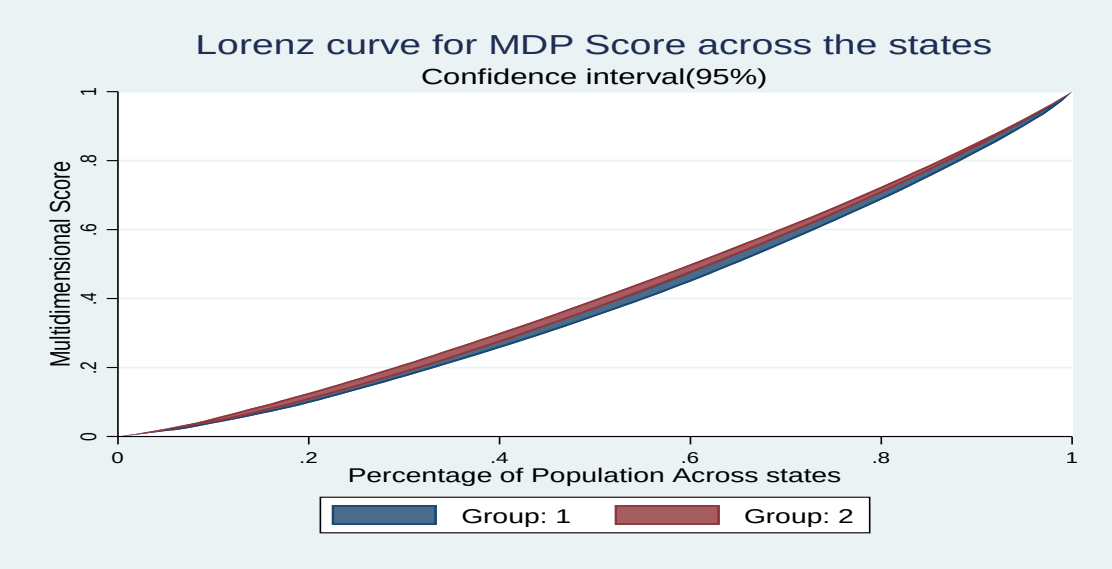

Figure 1: *Lorenz curve for multidimensional poverty score across the States*

The headcount ratio is the most common method measuring and reporting poverty. It counts the percentage of population that is below the poverty line. One of the undesirable features of the headcount ratio is that, it ignores the depth of poverty; if the poor become poorer, the headcount index does not change. Poverty gap index provides a clearer perspective on the depth of poverty. Nonetheless, across the States, Jigawa ranked top with over 93% of the respondents below multidimensional poverty line (Table 6) followed by Kano State with 89.7%, then Zamfara with 87.5%, Kaduna with 86.5% and the least was Katsina with 74.2%. The head count ratio across the two maize varieties shows that the population was 65.3%

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whereas; for NMZ, it was 65.5% and QPM was 62.3%. Although, there were discrepancies between the head count reported by NBS (2020) when compared to the findings of the current study, NBS reported that Jigawa has 87%, as against the current study with Jigawa 93.3%; also in Katsina NBS (2020) reported 56.42% but the current study found it to be 87%. Kano was reported to have 55.1% by NBS (2020) but the current study found the State to have 89.7%; these variations goes on all States in the survey.

The poverty gap index is the measure of the intensity of poverty. It is defined as the average poverty gap in the population as a proportion of the poverty line. It is also referred to as poverty gap ratio. This indicator is measures for the total population, as well as for people aged 18-65 years and people over 65 years. The poverty gap index is a percentage between 0 and 100%. Sometimes it is reported as a fraction, between 0 and 1. Therefore, a theoretical value of zero implies that no one in the population is below the poverty line. A theoretical value of 100% implies that everyone in the population has zero multidimensional score. The multidimensional poverty gap index or gap ratio in the population under the current study was 69.2% (Table 6). Because the average poverty gap is only for the poor, this measure provides the information on poverty depth of the poor and show how deep poverty occurs among the poor. The higher the average poverty gap is, the deeper the poor are in poverty, this implies that the average shortfall from the total population from the minimum level/threshold set for multidimensional poverty score required to secure the basic necessities for survival is 69.2%.

Consequently, the poor in the study were far away from the line set at 36.8%. However, across the State under study shows that Jigawa still ranked top with 76.6%, Kano follows with 72.6%, Zamfara with 70.1%, Kaduna with 69.0% and Katsina State with least value accounting for 55.2% (Table 6). The result for poverty gap ratio equally seems consistent with the findings of NBS (2020).

Table 6: Multidimensional Poverty Measures across States

	Poverty Measures				
State	**HC ratio**	**PG ratio**	**SPG ratio**	**Gini coefficient**	**FGT index**
Kaduna	0.8654	0.690607	0.47694	0.1850	0.5684
Katsina	0.7423	0.552463	0.30522	0.1230	0.5950
Zamfara	0.8750	0.70138	0.49193	0.5300	0.2186
Kano	0.8969	0.725957	0.52701	0.3900	0.6376
Jigawa	0.9328	0.766244	0.58713	0.1080	0.6773
Population	0.8911	0.692200	0.4795	0.2930	0.5812
p-value	0.0458**	0.0407**	0.0573**	0.0471**	0.0326**

Source: Field survey, 2020

Gini Coefficient

When all values of the distribution are equal, the covariance values under observation and the cumulative distribution function is zero. Therefore, the Gini index (1 - 2Z) is equal to zero. Therefore, the smaller the Gini values the less spread the level of inequality among individuals under study. However, where the level of inequality was higher, like, in Zamfara, there was widespread in inequality implying some were better off than others. The Gini index for the population was 55.6%, NMZ had 36.6% and QPM has 59.3% (Table 7). The report of Gini coefficient from National Bureau of Statitics, (2020) seems to align with the findings from

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this study. Table 6 shows the details description of the poverty outlook using multidimensional poverty approach across the maize type.

Table 7: Multidimensional Poverty Measures across Maize Type

Poverty Measures	Sample		Population	P-value
	NMZ	QPM		
Head count ratio	0.6552	0.6266	0.6525	0.0004***
Poverty gap ratio	0.4292	0.3926	0.4258	0.0009***
Square Poverty gap ratio	0.3763	0.1232	0.4746	0.0000***
Gini index	0.3664	0.593	0.5561	0.0000***
FGT	0.5761	0.7252	0.5746	0.0017***

Source: Field survey, 2020

Multidimensional Poverty Status by the Maize Type in Northwest Nigeria

There are six (6) components of multidimensional poverty used in the study namely; education, health, agricultural infrastructure, social exclusion, living standard; hazard and vulnerability each of these are construct drive from other variables. To get education dimension, farmers are ask on household school enrolment, distance to school, number dropout, number of out of school age children in such households including other household members without formal education. Table 8 provides details description of the components of multidimensional poverty index. These and many other were constructed as health component or dimension. Similar patterns were obtained for agricultural infrastructure, social exclusion, living standard, hazard and vulnerability. The work of Oxford Poverty and Human Development Initiative (2018) has provided an impressive direction for the extraction of multidiemnsional poverty dimensions. From each of these an index generated for the variable a name given to represent as the construct.

Table 8: Dimensions of Multidimensional by Maize Variety

Multidimensional Poverty	NMZ					QPM				
	Destitute	Very Poor	Poor	Better-off	Well-to-do	Destitute	Very Poor	Poor	Better-off	Well-to-do
Education dimension	0.762	0.675	0.819	0.244	1.040	0.412	0.286	0.427	0.113	0.006
Health dimension	1.313	1.274	0.969	1.058	0.832	1.238	0.967	1.068	0.784	1.401
Agricultural Infrastructure dimension	1.747	1.988	1.630	2.021	1.695	1.978	2.384	2.241	2.473	1.625
Social Exclusion dimension	2.093	2.182	2.375	2.174	2.153	1.718	1.502	1.764	1.259	1.636
Living Standard dimension	2.536	2.535	2.483	2.593	2.032	2.345	2.664	2.377	2.313	1.380
Hazard And Vulnerability dimension	0.723	0.886	1.160	0.642	0.511	0.784	0.810	0.940	0.949	1.576
Multidimensional poverty index	0.386	0.401	0.397	0.367	0.347	0.356	0.362	0.371	0.332	0.321
Aggregate Mean Poverty index	.5372	.8450	1.1532	1.7143	3.3584	.5339	.8030	1.1463	1.6794	5.7221

Source: Field survey, 2020

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Expenditure Poverty status by the selected States in Northwest Nigeria

Table 9 is on poverty status of selected farmers by State using aggregated household expenditure score per head per day and household multidimensional score. The study shows that 97 respondents out of the total of 119 households constituting about 82% of the sample farmers in Jigawa State are destitute; these findings coincide with the recent NBS (2020) release of 10 poorest State in Nigeria.

Table 9: Distribution of the Respondents on Poverty Status by Selected

State	Destitute	Very Poor	Poor	Better-off	Well-to-do	Total Households
Jigawa	97	14	6	2		119
Kaduna	124	56	14	10	4	208
Kano	125	23	10	5	2	165
Katsina	74	26	4	6	2	112
Zamfara	27	15	4	2		48
Total	447	134	38	25	8	652
Aggregate Mean Poverty Index	0.163911	0.442069	0.767519	1.347380	3.907438	1.32566

Source: Field survey, 2020

Also from Table 9, it was equally found that 14 farmers with about 12% were poor and only marginal numbers of farmers with about 2% are better-off; and no well-to-do among the sample farmers. Nevertheless, in Kano State, 125 respondents out of the 165 households about 76% of the sampled farmers were destitute, 23 farmers with about 14% were very poor households while only marginally 2 farmers with about 1% are well-to-do among the farmers selected. This finding has justified the claim made by Orokpo *et al.*, (2018) on the level of poverty in Nigeria.

Household Expenditure Poverty Status by Maize Variety

The average expenditure per head per day among destitute was ₦90.5; whereas among the very poor households in NMZ was ₦244.9 and poor household among NMZ farmer had an average of ₦410 per head per day. There is wide gap on expenditure between well-to-do households in NMZ side compared their counterpart in QPM side. The average expenditure poverty index for the two groups were reported in Table 10 similarly the aggregate mean poverty index for both expenditure and multidimensional were equally shown for each group and well as their category the farmers fall under.

Expenditure Poverty Intensity by Maize Type across States in Northwest Nigeria

Table 11 shows the details description of the poverty outlook expenditure across maize varieties. Distribution of expenditure by Maize variety shows that 71.7% of NMZ are destitute, 4.9% was poor with only 1.5% that was well-to-do. Also, 20.6% for QPM was very poor, 5.8% were poor, and only 3.8 were better-off (Table 11).

The Impact of Adoption of QPM on Household Poverty Alleviation

Table 12 presents the results of impact of adoption of qpm on household poverty alleviation in the study area. Impact assessment is a statistical method of establishing causal inference, is a topic of great significance in economics and related fields. Usually the impact of policy intervention is best established with causal effect. Several methods were use earlier in many studies such as the Randomized control trial, difference in difference, chow test,

regression discontinuity, and instrumental variable but they were found have many limitation and applicability in quasi-experimental design, which lead to development of propensity score matching methods. The four matching algorithm use in this work are nearness neighbor, kernel, radius, and stratified matching approach. The matching techniques have origins in experimental work from the several studies, they were used to ensure that the matching estimators identify and consistently estimate the treatment effects of interest (Stephen & Christopher, 2010; and Ademiluyi, 2014). Therefore, estimation of average treatment effects is an important issue in economic evaluations of the impact of policy intervention.

The average treatment effect (ATE) stands, and is commonly use as measure of causality. It uses a binary function model for treatment as dependent variable on a scalar outcome variable. The ATE, is the mean outcome difference between treatment and control groups, if they are randomly assigned to either of the group like during experimentation, where researcher control use random assignment to control and treatment. Regrettably, the method is subject to numerous biases. So the use of propensity score matching has evolve in order to capture the bias and correct such bias before the estimation ATE (Pan & Haiyan, 2015).

The use of propensity score matching (PSM) became handy in addressing the challenge of practicability of random assignment of individuals to treatment and control. Propensity score matching attempt to create treatment and control groups of similar pre-treatment attribute and thus mimicking randomized trials. After the estimation of propensity, score and bias removed through bootstraps, the outcome of the propensity score is subsequently use for the average treatment effect matching. The PSM has a distinctive model thus using a binary function of logit or probit model.

Table 10: Expenditure Poverty Status of the Respondents by Maize Variety

Expenditure Poverty at $192 per day	**NMZ**					**QPM**				
	Destitute	**Very Poor**	**Poor**	**Better-off**	**Well-to-do**	**Destitute**	**Very Poor**	**Poor**	**Better-off**	**Well-to-do**
Average Expenditure per head per day	90.5	244.9	410.0	721.9	1600.4	104.3	243.3	420.1	722.1	2862.6
Average Expenditure Poverty Index	-0.829	-0.536	-0.224	0.367	2.031	-0.802	-0.539	-0.204	0.368	4.422
Aggregate Mean Poverty index	0.5372	0.8450	1.1532	1.7143	3.3584	.5339	0.8030	1.1463	1.6794	5.7221

Source: Field survey, 2020

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Table 11: Distribution of Expenditure Poverty Status across States by Maize Variety

Expenditure Poverty Status	**NMZ**		**QPM**		**Pooled**	
	Frq.	**%**	**Frq.**	**%**	**Frq.**	**%**
Destitute	233	71.7	214	65.4	447	68.6
Very Poor	57	17.5	77	23.5	134	20.6
Poor	16	4.9	22	6.7	38	5.8
Better-off	14	4.3	11	3.4	25	3.8
Well-to-do	5	1.5	3	.9	8	1.2
Total	325	100.0	327	100.0	652	100.0
Measurement	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Average household expenditure poverty	.327977	.4569051	.367041	.7038008	.347509	.580353

Note: Frq. = Frequency; % = Percentage

Source: Field survey, 2020

Propensity score analysis used in Table 12 is a multi-step procedure used to equate groups for comparisons whose purpose is to reduce bias associated with non-randomization. To assess the impact of adoption of QPM on household poverty three different perspective were looked into thus expenditure poverty perspective, multidimensional poverty perspective and aggregate poverty perspective, and examine how each of these perspective was impacted by farmers adopting QPM. In all the three two stage models were use the first is to determine the factors that co-vary with the outcome variables using propensity score matching technique and controlled their effect using bootstraps regression, after which matching algorithms were performed and average treatment effect were estimated for each of the perspective.

Table 12 shows the details for the propensity score matching and bootstraps regression for all the perspectives. The first stage in the propensity score matching is to model the probability of being a QPM farmer or NMZ farmer. With that purpose, covariate variables are included as those variables that affect the likelihood of being QPM or NMZ farmer. The basis behind this is that, if a variable effects probability of falling into either of treatment or control category but not the outcome, then there is no need to control for differences with respect to this variable in the treatment against and the control groups. The implication of putting covariate is that if before the bootstrap the two groups are distinctly different, the estimate of PSM will not be stable, and hence the average treatment estimated with an unstable PSM is not consistent and unbiased, therefore conclusion drawn from it is misleading. Therefore, the need to bootstraps the standard error arises so that the bias in the two groups must be correct before estimating the Average treatment effect (impact). The general idea behind the bootstrapping in this study is to ensure that sample used in the study represents the population from which it was drawn. Therefore, resamples from this sample represent what to get if many samples was taken from the population. Variables that neither affect treatment nor the outcome are considered clearly as less important, as such, is removed from the analysis.

Therefore, only those variables that impact both the treatment and the outcome are needed achieved reliable matching outcome and are included in the probit model from which propensity score is derived. The Table 12 reported the co-efficient, standard error and t-values for all parameters for propensity logit and bootstrap regressions. One of the important parameter is the Pseudo-R^2 for logit and adjusted-R^2 for the bootstrap regression. They both

measures the percentage of the independent variables explaining correctly the relationship of the independent in determining the dependent variable, this parameter equally indicate whether relationship exist or not, other parameters are the coefficient, magnitude or rate of change of each variable in the relationship for both the two relationships. The table likewise reported significance of contribution by each variable as t-value. From the results (Table 12), the probit estimations shows the relatively good fit of the model, expressed by Chi-squared and Pseudo-R^2 statistics. The left hand side (expenditure poverty) is the probit estimate result on the conditional probability of a farmers being assign to QPM farmers as treatment group or NMZ farmers as comparison, given a set of observed covariates. The pseudo-R^2 for the model as 34.1% will remain the same in all the three (3) perspective since they are the same variables. Though, if the pseudo-R^2 was low suggesting that there should be no systematic differences in the distribution of covariates between both groups but if large, then there is need to run bootstraps to control for covariates between treatment and controls in order to allow them to be comparable. Guo and Mark (2015) in thier work claim that pseudo- R^2 of 12 is relatively high, and equivalent to about 50%-60% adjusted R^2 in linear regression. Ordinarily, the adjusted R^2 changes with outcome variable use; hence for expenditure poverty, it was 96.9%; for multidimensional poverty, it was 14.08% and the aggregate poverty, it was 15.5% (Table 13). The implication of the Pseudo R^2 implies that they have a likelihood of varying at 34%, the QPM between NMZ farmers using the covariate factors included, the likelihood ratio, chi-square is found to be significant. The adjusted-R^2 implies that after the bias are remove the adjusted-R^2 drops reasonably but still high with 96.9% for expenditure poverty, 14% for multidimensional and 15.5% for aggregate poverty. Among the covariates, included before the bootstraps age of the farmer, education, household size, land ownership, and States that the farmer come from positively affect the probability of falling into QPM or NMZ farmer category. More importantly, being female or male and having an experience in farming greatly increases the odds of cultivating QPM. In contrast, other variables, such as marital status, number of extension contact, maize total income do not strongly explain the likelihood of cultivating QPM.

After bootstrap and bias are remove for the co-variates variables, adjusted-R^2 changes, other included co-variates changes too though their initial effect are currently the features of the covariates variables equally changes remarkably. Those variables that are positive and significant at percentage (%) across the three perspectives are education and total maize output in expenditure poverty, while sex, age and group membership in multidimensional poverty but only maize output and State for aggregate poverty. Those variables that are significant and positive at 5% include value productivity in expenditure poverty, maize income and farm size in multidimensional poverty no variable that is significant at 5% in aggregate poverty. Those variables with positive and significant at 10% are household size, for expenditure, no variable in multidimensional and sex in aggregate poverty. Similarly, for negative but significant variables at 1% include sex, age, total income, group membership for expenditure, while multidimensional education and value productivity, in aggregate poverty it was marital status and maize yield. The coefficient for each implies the rate of change for the variable relative to the propensity score (Table 12).

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Table 12: Impact of Adoption and Productivity Quality Maize Production on Poverty Status of Rural Farming Households

Adoption of QPM	Expenditure Poverty						Multidimensional Poverty						Aggregate Poverty					
	Probit regression			Observed Bootstrap linear regression			Probit regression			Observed Bootstrap linear regression			Probit regression			Observed Bootstrap linear regression		
	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z
Constant	-4.933	0.722	-6.8***	-1.277	0.042	-30.6***	-4.933	0.722	-6.8***	0.296	0.05	5.96						
Sex	-0.35	0.136	-2.59**	-0.039	0.007	-5.34***	-0.35	0.136	-2.59**	0.039	0.008	5.06***	-0.35	0.136	-2.59**	0.0547	0.0316	1.73*
Age	0.001	0.007	0.13	-0.02	0.0052	-3.87***	0.001	0.007	0.13	0.045	0.009	4.74***	0.001	0.007	0.13	-0.0026	0.0027	-0.97
Education	0.024	0.012	1.91**	0.003	0.001	2.98***	0.024	0.012	1.91**	-0.003	0.001	-3.3***	0.024	0.012	1.91**	-0.0061	0.0059	-1.04
Marital status	0.205	0.082	2.5**	-0.001	0.006	-0.18	0.205	0.082	2.5**	0.001	0.006	0.19	0.205	0.082	2.5**	-0.1105	0.0402	-2.75***
Household size	0.002	0.04	-0.05	0.002	0.001	1.81*	0.002	0.04	-0.05	-0.002	0.001	-2.15**	0.002	0.04	-0.05	-0.0303	0.0068	-4.45***
Total maize income	0.014	0.0209	-0.67	1.8	0.375	-2.88***	0.014	0.0209	-0.67	0.043	0.171	2.52**	0.014	0.0209	-0.67	0.086	0.0217	3.96***
Maize yield	0.011	0.0025	4.48***	0.048	1.601	-0.03	0.011	0.0025	4.48***	0.816	162	0.05	0.011	0.0025	4.48***	0.0407	0.0667	-0.61
Total output	0.181	0.787	-0.23	0.0361	0.0129	2.8***	0.181	0.787	-0.23	0.086	0.0352	-2.44**	0.181	0.787	-0.23	-0.0411	0.026	-1.58
Membership	0.036	0.168	0.21	-0.033	0.009	-3.49***	0.036	0.168	0.21	0.032	0.01	3.15***	0.036	0.168	0.21	0.0346	0.0159	-2.18**
Amount credit	1.024	1.346	0.76	0.0482	0.0357	1.35	1.024	1.346	0.76	0.043	0.0377	-1.14	1.024	1.346	0.76	-0.1448	0.0796	-1.82*
Farming experience	0.756	0.26	2.91***	0.028	0.036	0.76	0.756	0.26	2.91***	-0.027	0.033	-0.81	0.756	0.26	2.91***	0.0473	0.089	0.53
Total Factor productivity	-0.664	0.373	-1.78**	-0.038	0.019	-1.96**	-0.664	0.373	-1.78**	0.037	0.027	1.37	-0.664	0.373	-1.78**	-0.3845	0.161	-2.39**
Value productivity	-0.559	0.508	-1.1	0.103	0.046	2.27**	-0.559	0.508	-1.1	-0.103	0.037	-2.8***	-0.559	0.508	-1.1	0.0083	0.0095	0.87
Number of extension visits	-0.115	0.059	-1.96**	-0.005	0.011	-0.49	-0.115	0.059	-1.96**	0.005	0.011	0.49	-0.115	0.059	-1.96**	0.0111	0.0528	0.21
Total maize farm size	0.329	0.141	2.34**	-0.018	0.011	-1.72*	0.329	0.141	2.34**	0.018	0.008	2.37**	0.329	0.141	2.34**	0.0571	0.0361	1.58

***significant at 1%; **significant at 5%; * significant at 10%

Source: Field survey, 2020

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Table 12: Impact of Adoption and Productivity Quality Maize Production on Poverty Status of Rural Farming Households **Cont'd.**

Adoption of QPM	Expenditure Poverty						Multidimensional Poverty						Aggregate Poverty					
	Probit regression			Observed linear regression	Bootstrap		Probit regression			Observed linear regression	Bootstrap		Probit regression			Observed linear regression	Bootstrap	
	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z
State	0.305	0.047	6.54***	0.002	0.003	0.89	0.305	0.047	6.54***	-0.002	0.003	-0.94	0.305	0.047	6.54***	1.3386	0.2684	4.99***
Number of observations			652			652			652			652			652			652
LR chi2(12)			308.27	Wald chi2(18)		3550.4	LR chi2(12)		308.27	Wald chi2(18)		140.81	LR chi2(12)		308.27	Wald chi2(18)		365.32***
Prob > chi2			0.000***	Prob > chi2		0.000***	Prob > chi2		0.000***	Prob > chi2		0.000***	Prob > chi2		0.000***	Prob > chi2		0.000***
Log likelihood			-297.79	R-squared		0.9702	Log likelihood		-297.8	R-squared		0.1646	Log likelihood		-297.79	R-squared		0.1772
Pseudo R^2			0.3411	Adj. R-squared		0.9694	Pseudo R^2		0.3411	Adj. R-squared		0.1408	Pseudo R^2		0.3411	Adj. R-squared		0.1551

*****significant at 1%; **significant at 5%; * significant at 10%**

Source: Field survey, 2020

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Common Overlap Support for Average Effect of Adoption on Expenditure Poverty

The common overlap support graph for average effect of adoption on expenditure poverty is presented in Figure 2. Before the matching algorithm for the three perspective thus expenditure poverty, multidimensional and aggregate poverty, common support overlap was tested. The implication of common support depicts the data for QPM and NMZ are comparable if no support then two (2) groups are comparable. Average treatment estimated is not consistent. It is diagnostic tool for estimating average treatment, which has to be tested. Based on the figure it is clearly shown that common is achieved no any individual either from treatment of control that is off supports, hence, with this matching will give a consistent average treatment, for expenditure poverty.

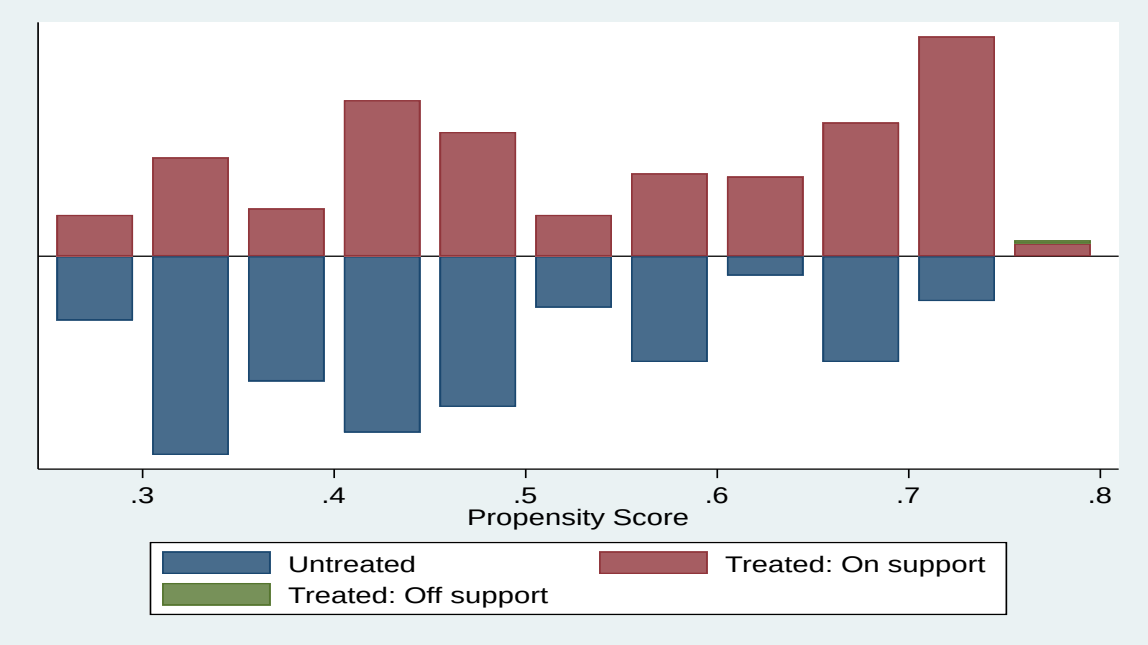

Figure 2: *Overlap support graph for average effect of adoption on expenditure poverty*

Support Overlap Graph for Average Effect of Adoption on Multidimensional Poverty

Figure 3 depicts common support overlap graph for average effect of adoption on multidimensional poverty. The common graph for multidimensional poverty presented in Figure 3 shows that few QPM farmers were off support, hence, such individuals are drop from further analysis since they are non-comparable with any individual in the NMZ group since for the aggregate, it is derived from the combination. ATT if sufficient will ensure the existence of potential matches in the control group, whereas for ATE, it is additionally required that the combinations of characteristics in the comparison group may also be observed in the treatment group (Marco & Sabine, 2005; and Stephen & Christopher, 2010). Several ways are suggested in the literature, where the most straightforward one is a visual analysis of the density distribution of the propensity score in both groups. Although (Guo & Mark, 2015; and Govindasamy, 2016) argues that support problem can be spotted by inspecting the propensity score distribution, there is no need to implement a complicated formal estimator. However, some formal guidelines might help in the procedure to determine the region of common support

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more precisely. Implementing the common support condition ensures that any combination of characteristics observed in the treatment group can also be observed among the control group (Pan & Haiyan, 2015; Govindasamy, 2016).

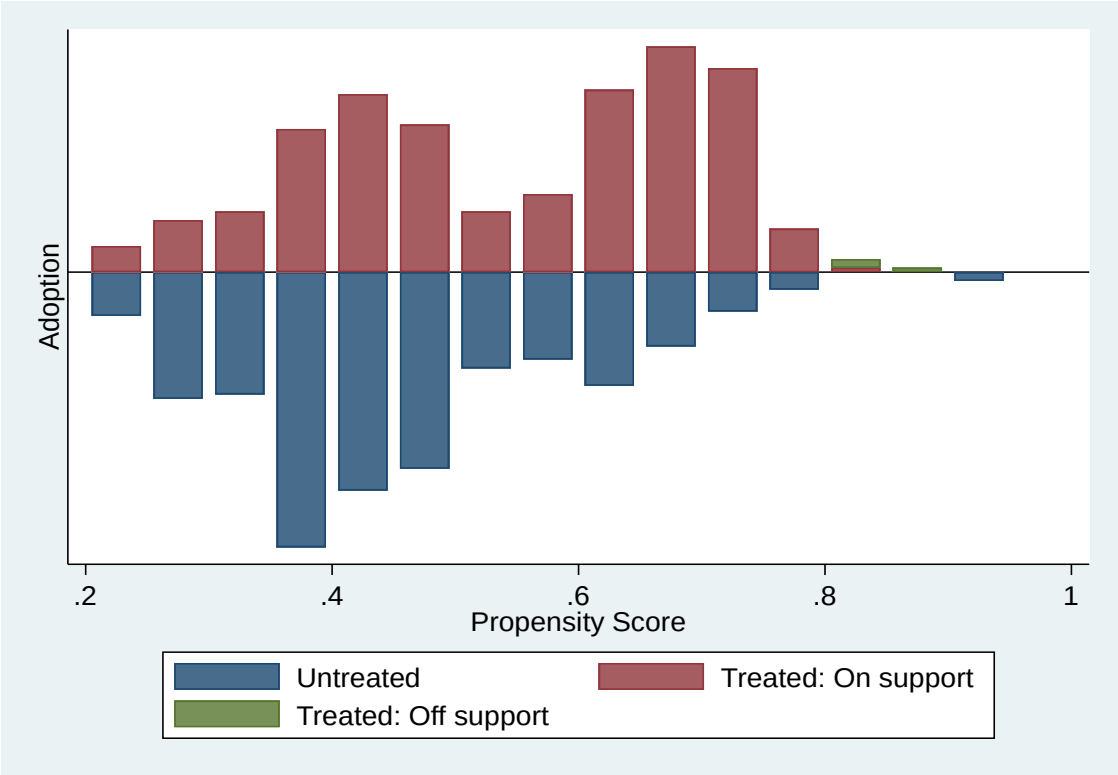

Figure 3: *Support overlap graph for average effect of adoption on multidimensional poverty*

The final stage is matching algorithm that will pave way for the estimation of average treatment effect and potential outcome mean for the three perspectives. The core idea of matching, after obtaining estimated propensity scores, is to estimate the average treatment effect, and potential outcome mean. Matching algorithm is a procedure of paring identical/undistinguishable values of the propensity score to examine the similarly or otherwise. The study applied four (4) matching methods. Nearness neighbours, radius matching, kernel matching and stratified matching methods.

The result in Figure 3 shows that adoption increases expenditure poverty index by 6.8% using nearness neighbours method, 4.3% using radius matching methods, 6.9% using Kernel matching methods, and 2.8% using stratified matching method. Similarly, the result shows that adoption reduces multidimensional poverty among farmers by about 4.7% using nearness neighbours matching methods, 2.6% using radius methods, 2.3% using kernel matching methods, and 2.1% using stratified matching method. The result equally shows that, adoption of QPM reduces aggregate poverty index increases by 8.8% using nearness neighbours method significant at 5%; 7.3% using radius-matching methods was also significant at 5%; 5.7% using Kernel matching methods significant at 5%; and 6.8% using stratified matching method also significant at 5%.

After the matching, average treatment was estimated, the result shows that average treatment for expenditure poverty among treated was 4.5%, which is significant at 10%.

Regrettably, this finding contradicted the report of Olawale (2018). Furthermore, the average treatment effect between treated and non-treated individual in the study is 1% lower on multidimensional poverty, it equally has a potential outcome mean of 60.7%, which is significant at 1% on the same multidimensional poverty measures. The result agreed with findings of Musa *et al.* (2017). The average treatment among treated (ATT) was 4.4% difference significant at 5%. Nevertheless, average treatment effect (ATE) was 2% this shows that for farmers to be out of multidimensional poverty index when adoption of farmers for quality protein maize increase the multidimensional poverty index will reduce by 2% significant at 5%. This result is in line with findings of Musa *et al.* (2017) and and Akinrinola and Adeyemo (2018). Nevertheless, the average treatment for aggregate poverty shows that average treatment effect among treated was 2.8% significant at 5%. Also, 3.8% was reported as average treatment effect between farmers producing QPM and those that produce normal maize (Table 13). Although, potential outcome mean (POM) for multidimensional poverty shows that 34.7% and significant at 1%, thus if farmers had not have adopted quality protein maize, their productivity will remain as it is so poverty will be lower by 34.7% lower (Table 13). Based on the result of the ATT, ATE, and POM (Kieisuke *et al.,* 2003) believe that 1% ATT and ATE is great (Marco & Sabine , 2005). The mean potential outcome was 60.7% and significant at 1% in aggregate poverty.

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Table 13: Average Treatment Effect for Assessment of Impact of Adoption of Quality Protein on Household Poverty Alleviation

Matching Algorithm	**Multidimensional Poverty**					**Expenditure Poverty**					**Aggregate Poverty**				
Poverty	**ATT**	**P.Score Before**	**P.Score After**	**Bias**	**t-value**	**ATT**	**P.Score Before**	**P.Score After**	**Bias**	**t-value**	**ATT**	**P.Score Before**	**P.Score After**	**Bias**	**t-value**
Nearness neighbors	-0.047	0.050	0.0241	0.0115	-1.960**	0.068	0.126	0.07618	0.02	1.898*	0.088	0.133	0.1364	0.01343	2.018**
Radius	-0.026	0.009	0.0090	0.0019	-2.87***	0.043	0.047	0.04854	0.001	2.878***	0.073	0.058	0.0603	0.00229	-2.329**
Kernel	-0.023	0.019	0.0173	0.0015	-1.856*	0.069	0.06791	0.0665	0.00	2.033**	0.059	0.0756	0.0793	-0.0037	2.33**
Stratification	-0.021	0.011	0.0129	-0.0007	-1.645	0.028	0.069	0.06672	0.0051	1.418	0.068	0.069	0.0706	-0.0041	-2.126**
Treatment effects			**Coef.**	**Std. Err.**	**z-value**			**Coef.**	**Std. Err.**	**z-value**			**Coef.**	**Std. Err.**	**z-value**
ATET seed code (1 vs. 0)			-0.044	0.03192	-2.37**			0.04526	0.067	1.68*			0.0281	0.09298	2.03**
ATE seed code (1 vs. 0)			0.020	0.01036	2.02**			-0.01	0.0104	-2.01**			-0.038	0.06521	-2.58**
Potential outcome mean seed code 0			0.347	0.00825	42.07***			-0.6073	0.0239	-25.4***			0.7421	0.04299	17.26***

***significant at 1%; **significant 5%; *significant at 10%

Source: Field survey, 2020

CONCLUSION AND RECOMMENDATIONS

The study concluded that the assertion that adoption of quality protein maize (QPM) variety does not affect poverty status of the maize-farming households in Northwest Nigeria was rejected and alternative accepted as truth based on causal outcome mean (otherwise potential outcome mean) of 65.6% for expenditure poverty and 38.6% for multidimensional poverty. Thus, farmer that do not adopt QPM are likely have currently have a multidimensional poverty value of 38% but had they choose to produced QPM their multidimensional poverty will reduced to 34.7% multidimensional poverty. This implies that what they lack they can now have more which will reduce the lack they experience currently. On expenditure poverty, their current poverty status was 33%; had they choose to produce QPM, the expenditure poverty index would move to 61% expenditure poverty implying that they can spent more compared to what they are currently spending, i.e., improvement in their livelihood. Nevertheless, for aggregate poverty their current value was 45%; and if they choose to produce QPM, their aggregate poverty would move from 45% to 74% aggregate poverty. The study therefore, recommended increase in the publicity of QPM through bulletin, guide, and radio jingle in the study area.

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