IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 15, Issue 11 Ser. II (November 2022), PP 38-45
www.iosrjournals.org

Productivity Effects of Petroleum Products' Consumption Among Farm Households In Nigeria.

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Abstract.
In Nigeria, petroleum sector is poorly linked to the agricultural sector and the country's considerable endowment in the resources has not turned into substantial improvement in agricultural productivity. It has, therefore become important to lay empirical evidence on the effect of petroleum product consumption on agricultural productivity of farm households in Nigeria. The data used were secondary and covered the four waves of the General Household Survey, (GHS) Panel that spanned the period from 2010 to 2018. The data included output and area plantedto staples, mainly cereal grains, grain legumes roots and tubers, amount spent on the consumption of three selected petroleum fuels namely gasoline or petrol, diesel and kerosene, quantity and amount spent on consumption of fertilizer and agrochemicals, use of machinery, and mandays of farm labour consumed. Data source was mainly the National Bureau of Statistics(NBS). Data were analysed using descriptive statistics and fixed effect regression model. Results showed that use of farm machinery powered by petroleum fuels have significant effect of 0.11 on agricultural productivity at $p < 0.01$. Mandays of labour had significant effect of 0.7 on agricultural productivity at $p < 0.01$, access to credit had significant effect of 0.12 on agricultural productivity at $p<0.01$. Policy modification should focus on strengthening the agricultural institution capacity for efficient management and implementation of agricultural mechanisation strategy, and credit delivery should target and reach rural farm households timely during the planting season. Technology development that will generate alternative energy to power farm machinery is crucial.

Keywords: ***Petroleum Products, Agriculture, Productivity, Farm Household***
JEL Classifications: Q12, R20.

Date of Submission: 14-11-2022 Date of Acceptance: 28-11-2022

I. Introduction.

Agricultural productivity is a direct function of high yield varieties, agro-chemicals, fertilizers, and farm mechanization which is directly linked to petroleum consumption. As agricultural production becomes more mechanized, petroleum products become crucial inputs as they affect the level and scale of many other agricultural inputs consumption in Nigeria due to lack of alternative energy source such as solar driven machinery for agricultural production.Consumption of petroleum products has been pointed out as the most expensive input when farming integrates mechanisation and improved farm technologies (Hassanien et al 2016). Petroleum products are the largest energy sources in agriculture (Soni et al 2013, Xi Chen et al 2020). In 2016, the world agricultural industry consumed 198million tonne of oil equivalent, which includes 104 million tonnes of petroleum products (Xi Chen et al 2020).

In Nigeria, gasoline is the most common and widely consumed petroleum fuel.In the country the product has huge benefit in the activity sectors of the economy serving as input for production (Akinyemi et al., 2015). The volume of gasoline consumed annually is about 13.3 billion litres which amounts to 83.9% of the total refined petroleumfuels domestically consumed. In recent years, there has been evolution of mechanized farms in Nigeria featuring large farm size of agricultural production and agro-based industries such as feed mills, hatchery, poultry, piggery, as well as well-equipped mechanical workshops.These farms make use of petroleum in various forms for their daily operations. It is recognised in agricultural production and processing that farm power is the second most important input apart from land. Since 2013, initiatives such as the cassava mechanisation and agro-processing project (CAMAP) have increased the adoption of mechanisation for crop production among farmers in Nigeria by providing implements such as planting and harvesting machines to farmers' clusters. The project has trained and empowered many clusters of farmers in the country, hence the increase in the use of petroleum products.

However, the petroleum sector in Nigeria is poorly linked to the agricultural sector and the country's substantial endowment in the resources has not yielded substantial improvement in agricultural productivity and welfare of rural farm households (Ighosewe et al., 2021). Welfare of rural farm households is uptight with poor energy supply. Petroleum product prices have been adjusted upward abruptly by different government administration over the years since 1970s to date. Such upward petroleum price review at various times has witnessed the outcry of producers and owners of business firms on its implication on production cost and output since most of them rely on petroleum fuels as alternative source of energy. Consequently, intense debates and articles on the media have also been frequent on the possible adverse influence of such petroleum price reviews on firms' production cost and productivity of different sectors of the economy. Given the prevailing high cost of petroleum fuel in the country, transportation cost is climbing limiting the linkage of farm households to the market, giving rise to high delivery cost of moving farm inputs to the farm and farm output from farms to output market. This aggravates inadequate supply of agricultural inputs at the farm thus constraining application of technology and innovation which results into low productivity and low income of rural farm households. Farm hhouseholds with low incomes have limited access to petroleum products and machinery that require their use. Nigeria's mechanization rate of 0.27horsepower per hectare is well below the Food and Agriculture Organisation's (FAO) recommended rate of 1.5horsepower per hectare. This worsen not only the low agricultural productivity but also fostered low domestic food supply or lack of self- sufficiency in food supply. High cost of petroleum fuels as alternative source of energy consumption is crowding out investment in agroindustry in Nigeria and the potentials of the industry remained not fully exploited. The desired goals of improving rural farmer's productivity has not been achieved with little or no alternative source of affordable energy for the rural farm households (Azeez, 2018). Undoubtedly, the desired high productivity level expected from agriculture has been constrained by fragmentation of farmland which restrains the use of petroleum products in modernizing agriculture through mechanization. This imposes limitation on the level of agricultural productivity and the welfare of rural farm households in Nigeria.

Over the years, different agricultural programmes have been implemented in Nigeria in order to increase agricultural productivity. These include growth enhancement programme under the Agricultural Transformation Agenda (ATA), Commercial Agriculture Credit Scheme (CACS), and Anchor Borrower's Programme (Central Bank of Nigeria, 2021). One of the policy priorities for the current Medium Term National Development Plan(MTNDP) and National Agricultural Technology and Innovation Plan(NATIP) 2021 to 2025, for Nigeria is to enlarge agricultural output for food security through improved production systems and technology that will nurture increased agricultural productivity. In the improved technology and production system, engines and motors using petroleum fuels are vitally important in Nigeria as alternative source of energy to power machines such as tractors, threshers, mill, irrigation pumps, and grinders for production, harvesting, processing and handling of agricultural products through agricultural mechanisation. Agricultural mechanisation is the key operational input for improving productivity of farmers. Addressing the cost of petroleum products consumed is important if the country wants to achieve her set goals of lifting about 100 million populations out of poverty by 2030. Gasoline and diesel, are used to power agricultural machines, processing machines, and to transport inputs such as fertilizer, pesticides to the farms and final goods to the ultimate consumer. The coverage of agricultural activities in Nigeria using gasoline and diesel include ploughing, harrowing, ridging, fertilizer application, spraying, planting, weeding, harvesting, and processing among others. In addition, kerosene is a major petroleum product used for lightening and cooking in the rural Nigeria. Fertilizer and agrochemicals are important agricultural inputs derived from petroleum. They are inputs used by farmers to enhance agricultural yield and for controlling pests and diseases. Agricultural households represent the section of the sub-Saharan African population that matter most for agriculture-led, welfare-improving initiatives.Most previous studies concentrated on aggregate macroeconomy but ignored the analysis of the effect of petroleum products on agricultural productivity. Indigenous studies in this regard such as (Nkang, 2018; Aniekan *et al.* 2018; Nwoko *et al.* 2016) among others, have neglected the farm household level analysis in their work. These prompts the need to lay empirical evidence on the effect of petroleum product consumption on agricultural productivityof farm households in Nigeria.

The paper is organised into five sections. Section one focused on introduction. Section two contains the theoretical framework of the study. Section three focusses on the methodology adopted. Section fourconcentrates on discussion of the results. The paper is concluded in section five with policy recommendation and final remark.

II. Theoretical Framework

Agricultural Production Theory

Theory of agricultural production provides a theoretical anchor for the study from which the paper is culled. Production is the process of combining factors of production in the creation of a good or service. Producing some amount of agricultural product, requires in addition to suitable climatic conditions, some

amount of arable land, seed, human labour, fertilizer, agrochemicals, the services of farm machinery and equipment which consumes some amount of petroleum fuels. It seems reasonable to assume that production will vary in a systematic way with the levels of input usage. The relationship between the inputs and outputs is referred to as production function.

In mathematical form a production function is defined as

$Q = f(X_1, X_2, \ldots Xn)$ …… (3.1)

where Q denotes the quantity of a specific product produced in a given time period; and X_1……. Xn represent the quantities of a number (n) of inputs employed in the production process.

The expression in 3.1 merely states that output is related to the levels of input usage. The production function depicts the maximum output for each and every combination of specified inputs used in the production process. It relates to a given state of technology.

Hence, the level of technology imposes production constraint on the household in terms of what and how much to produce. The level of technology is represented by the production function relating outputs to inputs. The inputs used in the production process can be categorized into labour, non-labour variable inputs and fixed inputs. Therefore, with consumption of petroleum products, the production function is expressed as:

$Q_a = f(N_i, K_i, L_i)$ ……(3.2).

Q_a = output of agricultural products produced by the household

N_i = non-labour variable inputs used for production such as seeds, fertilizer, agrochemicals, petroleum fuels (gasoline, diesel);

L_i = Labour inputs used,

K_i = fixed inputs (land for production and storage, farm machinery).

Agricultural productivityis defined as a ratio of a volume measure of output to a volume measure of input used (FAO,2017). At its most fundamental level, productivity measures the amount produced by a target farm given a set of resources and inputs. Productivity measures are always volume based, either expressed in physical quantities, or in constant value terms, implying that values be adjusted for price change. The productivity of the land measures the amount of output generated by a given amount of land. It is mostly applicable in the context of cropping activities, but it can also be extended to livestock production. There are several productivity measures that can be calculated, a broad measure is the ratio between the value of all agriculture products (crops and livestock) and the total land used in agriculture. Other land productivity measures can be calculated by dividing crop production by the amount of planted land, expressed in an area unit, such as hectares. When expressed in terms of physical output, such as tonnes of maize, land productivity corresponds to crop yields. When expressed in monetary terms, land productivity is more often referred to as returns to land(FAO,2017).

III. Methodology.

3.1 Study Scope, Types and Sources of Data

The scope of the study from which the paper wasextractedis rural Nigeria representing 48.04 per cent of the country's population (World Bank, 2020). The presence of multiple vegetation zones, abundant rain, surface water and underground water resources and moderate climatic extremes, allow for production of diverse food and cash crops by over 60% of the population making the agricultural sector to be the chief employer of the country's total labour force, providing livelihood for about 90 percent of the rural population (IFAD, 2020). The secondary data that were used in the study is the General Household Survey-Panel collected by National Bureau of Statistics in conjunction with the Federal Ministry of Agriculture and Rural Development (FMA&RD), the National Food Reserve Agency (NFRA). Both urban and rural enumeration areas (EAs) were canvassed. However, this study utilized the rural EAs only. The first wave of the GHS-Panel was carried out in two visits to the panel households (post-planting visit in August-October 2010 and post-harvest visit in February-April 2011). The second wave of the GHS Panel was carried out in two visits (post-planting visit in September – November 2012 and post-harvest visit in February-April 2013). The third wave was carried out in two visits (post-planting visit in September – November 2015 and post-harvest visit in February-April 2016). The fourth wave was also carried out in two visits (post-planting visit in July - September 2018 and post-harvest visit in January - February 2019). Information were obtained from the same set of households in the four waves.The data used covered the four waves of the General Household Survey, (GHS) Panel data, that spanned the period from 2010 to 2018. The data included output and area harvested of staples, mainly cereal grains, grain legumes roots and tubers, amount spent on the consumption of three selected petroleum fuels namely gasoline or petrol, diesel and kerosene, quantity and amount spent and quantity on consumption of fertilizer and agrochemicals, use of machinery, and man-days of farm labour consumed.

3.2 Analytical techniques

The analytical techniques that was employed in the study to achieve its objectives are descriptive statistics, and fixed effect model.Descriptive statistics such as frequency, percentage and mean were used to profile the consumption of petroleum products, and agricultural productivity. Consumption of petroleum fuel was measured by considering amount spent of each of the products (kerosene, diesel, gasoline). Agricultural productivity was measured using value of agricultural output per hectare.Farm household consumption of each of the petroleum fuels was proxied by valued cost of each petroleum fuel, gasoline(petrol), diesel and kerosene, since the volume of each of the petroleum fuels consumed by the farm household was not available in the four waves of the GHS Panel Data. The nominal value of the annual amount spent on each product which was available was obtained directly from the GHS panel data. In order to obtain real value of each fuel, the nominal value was deflated by inflation rate obtained from the same source, National Bureau of Statistics, for the respective wave of the GHS. Real value of each fuel consumed was summed up to obtain the aggregated value of petroleum fuels consumed by the farm household.

Output of each agricultural commodity produced by the household was obtained directly from the GHS. Selected agricultural commodities included the major staples essentially cereal grains, legumes, roots and tubers that constituted the bulk of the major staples produced and consumed by farm households across the geopolitical zones in Nigeria. Value of each agricultural output produced was obtained by the product of the output and the respective producer price obtained directly from the GHS. Values of the agricultural output with respect to the selected commodities were summed up to obtain aggregated values in nominal terms. The nominal value of each agricultural output produced in each wave was deflated by the inflation rate for the respective wave to obtain the real value for each product. Real values for all products were aggregated and divided by land hectarage planted of the selected commodity to obtain the agricultural productivity that was used to proxy agricultural productivity per hectare. All monetary measurements of variables were in their real forms for comparison across the different waves of the GHS. Fixed effect (FE) model was applied to determine the effects of petroleum products' consumption on agricultural productivity among farming households. The FE remove the effect of time-invariant characteristics (gender) and captured in the error term in order to assess the net effect of the predictors (kerosene, diesel, gasoline) on the outcome variable (agricultural productivity). A regression model given as follows was used to determine the effect of petroleum fuels consumption.

3.3 Specification of Empirical Model:

On the basis of production theory and the general production function in (3.1) and (3.2) the empirical model for the study is specified as:

$$Agric_{Pro} = \varphi_{it} + \alpha 1 D_{it} + \alpha 2 P_{it} + \alpha 3 Xit + \ \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

Where, $Agric_{Pro}$ is the measure of agricultural productivity as defined above, D is the demographic and socioeconomic characteristics of i_{th} household at time t, P is the total amount spent on petroleum fuels as earlier defined , ε is the error term, φ is the household fixed effect which captures unobserved household heterogeneity while α are the vectors of parameters that were estimated. The dependent variable is agricultural productivity, X_i is a vector of quantities of inputs such as seeds, fertilizer, herbicides and pesticides. We expect all the socioeconomic variables, farm technology variables as well as petroleum products consumed to contribute positively to agricultural productivity. The vector of household and community characteristics mainly demographic and socioeconomic household characteristics included the education, age, gender, of household head, sex of household head, marital status, landholdings, ownership of storage facilities, ownership of mobile phone, household size, access to extension services, access to remittances, and access to credit, and ε_{it} is the error term. The agricultural commodities covered included cereal grains, grain legumes, roots and tubers and they constitute the major consumption food basket across the geopolitical zones of Nigeria.

IV. Results and Discussion.

4.1Structure of Expenditure on Petroleum Products Among Farm Households.

In this subsection, the study profiled the consumption of the selected petroleum products, using the 4 waves of the GHS panel data. Table 4.1 presents the result of the summary statistics that show the pattern of petroleum products consumption and the use of farm machinery. It is worthy of note that the statistics do not reflect the volume of each of the petroleum fuel consumed because the volume of each fuel consumed by the farm households were not reported. Farm household reported only the amount invested in the use of each of the petroleum fuel, hence the pattern of consumption was proxied by the amount invested in the consumption of each fuel. The nominal consumption was adjusted for inflation by converting the nominal naira values to indicator of real values for comparison across the waves. Note that the statistics are the indicators of real values after the adjustment for the rate of inflation. So, in real terms, the result revealed that, on the average, there was an increase in the average expenditure on the consumption of all selected petroleum fuels from about ₦115.84 in 2011 to ₦185.41 in 2013 while it declined steadily to about ₦102.31 in 2016 and then increased substantially

to ₦272.32 in 2019. The consumption pattern fluctuates across the waves with substantial increase in the fourth wave (2018/2019). In addition, the result revealed that there was no distinct pattern in the amount spent on kerosene across the periods with the least amount

Table4.1: Pattern of Petroleum Products'Consumption and Use of Farm Machinery Among Farm HouseholdsAcross the Four Waves.

	Kerosene	Petrol	Diesel	Fertilizer	Agrochemicals	Use of Machinery (Yes=1)	Total
Consumption Expenditure in Real Naira Value.							
Wave 1 2010/2011	38.41	71.76	5.67	648.75 (84.68)	73.51 (2.34)	102	838.1
Wave2 2012/2013	56.44	127.3	1.67	869.4 (93.31)	171.06 (3.87)	122	1225.87
Wave3 2015/2016	31.66	64.84	5.81	493.95 (64.16)	247.82 (5.64)	169	844.08
Wave4 2018/2019	47.15	218.8	6.37	687.95 (121.40)	97.44 9.99)	33	1057.71
Percentage Share of the Total Expenditurefor Each Petroleum Product.							
2010/2011	4.58	8.56	0.68	77.41	8.77	-	100
2012/2013	4.60	10.38	0.14	70.92	13.95	-	100
2015/2016	3.75	7.68	0.69	58.50	29.37	-	100
2018/2019	4.46	20.69	0.60	65.04	9.21	-	100

Note: Figures in parentheses are the quantity in kg for Fertilizer and Agrochemicals.
Source: Computed using the 4 waves of the Nigeria GHS panel data

of about ₦31.66 spent in 2015/2016 period and highest average amount of ₦56.44 spent in 2012/2013. In the same vein, the consumption of petrol (gasoline) increased from ₦71.76 in 2010/2011 to ₦127.30 in 2012/2013. Thereafter, it declined to ₦64.84 in 2015/2016 but increased substantially to ₦218.80 in 2018/2019. On the overall, the consumption of petrol was higher than other petroleum fuels across the waves. This indicates that consumers consumed more of petrol than any of the three selected petroleum fuels over the period. This might be because they used more petrol to power their farm machinery, generators and means of transport, vehicle and motorcycle, as well as for charging their phones.

Regarding the consumption of Fertilizer and agrochemicals that are derived from petroleum, as well as the application of farm machinery in farm operations, the results presented in table 4.2 shows the pattern of application of the inputs in agricultural practices across the 4 waves of the panel data. On the average, in real terms, the table revealed that there was a continuous increase in the quantity and cost of fertilizer consumed across the periods. In the 2010/2011 season, farmers expended about ₦648.75 for the consumption of 84.68 kg of fertilizer, while they spent about ₦687.95 for the consumption of 121.40 kg in 2019. However, the result further shows that the quantity of fertilizer used across the different periods of the panel increased from 84.68kg to about 121.4kg in 2019 except in 2015/2016 season where there was a reduction in the quantity of fertilizer used to about 64. 16kg. The pooled result showed that farmers utilized an average of 90.89kg at a real cost of ₦674.92 over the entire periods.

In respect of the real cost of agrochemicals, the result revealed that there was a sporadic increase also in real cost except for a decline observed in 2018/2019 period. Nonetheless, the quantity of agrochemicals used increased consistently over the entire periods. For instance, the result showed that about 2.3kg of agrochemicals was used in first year of the panel data while about 3.9kg, 5.6kg, and 10.0kg was used in the 2^{nd}, 3^{rd}, and 4^{th} waves of the panel respectively. This might be due to increase in the level of farmer's need to control weeds, pests, and diseases on their farm. The pooled result therefore showed that average quantity used was 5.5kg of agrochemicals across the periods at the average real cost of ₦147.46. Considering the use of machinery, the result revealed that 102 farmers used machinery for their farm operations to supplement the use of man power in the 2010/2011 farming season while in the 2012/13 and 2015/16 seasons, 122 and 169 farmers used machinery on their farm plots for tractions. However, in the 2018/19 season, this number dropped to 33 farmers. This implies that many farmers were able to used machinery on their farm in the earlier periods of the panel than in the later periods of 2018/2019. The investment cost for the use of machinery were not reported by the farm households.

Overall, the results presented in 4.1 showed that in real terms, fertilizer consumption accounted for the highest cost of investment outlay incurred on the five petroleum products among the farm households across all the four waves in real terms. Fertilizer accounted for 77.41 percent, 70.92 per cent, 58.50 per cent and 65.04 per

cent of total cost of investment on the five petroleum products in the first, second, third and fourth wave respectively. This was followed by agrochemicals, petro(gasoline), kerosene while diesel trailed last in the order of importance. One important deduction for policy focus in the pattern of consumption of petroleum products from the results in table 4.2 is that an increase in the use of farm machinery by the farm households across the waves. This might have enabled an increase in the consumption of petroleum fuel especially gasoline(petrol), fertilizer, and agrochemicals by the farm households across the four waves. This suggests that an increase in the use of petroleum products in combination with farm machinery are crucial to enhance agriculturalproductivity among the farm households.

4.2 Trend of Agricultural Productivity Among Farm Households.

In estimating agricultural productivity, one limitation of the data on the yield of different agricultural output is that they cannot be directly aggregated because of the differences in water content and grain equivalence. In order to minimize error in the aggregation, the product of the output figures and producer prices for the respective selected staple food commodities were computed and summed up to obtain aggregated value of agricultural outputs. This was divided by the number of hectares planted to obtain nominal value of agricultural output per hectare. The nominal values of agricultural outputs for each wave was adjusted by the respective inflation rate of each wave to obtain the real value of agricultural output for each wave. Subsequently, the real value of each agricultural output was divided by the total hectarage planted to obtain the real value of agricultural output per hectare.This was used as a proxy indicator to measure agricultural productivity per hectare among the rural farm households.

Considering the productivity pattern, Table 4.2 presents the result of the pattern of the productivity per hectare as well as land and labour use pattern across the periods of the panel data. The table shows that the average real value of agricultural output per hectare in the first period was about ₦75,443.74 which declined in the second period (2012/2013) to ₦64,433 per hectare and then increased to about ₦125,802.12 per hectare in the third period of the panel even though it later reduced in the 4th period to about ₦104,484.37 per hectare. This implies a fluctuation in the total value of output per hectare produced by the farmers over the periods. On the contrary, the average farm size declined across the first three periods but there was a slight increase in the average farm size between third and fourth period from 0.9ha to 1.1ha. The decline observed in the average farm size might be due to increased utilization of improved inputs and practices which could also lead to a reduction on the pressure or demand for land for agricultural purpose. The same table also shows that the labour use pattern declined from 183mandays in 2010/2011to 129mandays in 2012/2013 but there was a sharp increase to 209mandays in 2015/2016 before a sharp decline to 146 mandays in 2018/2019.

Table 4.2: Pattern of Agricultural Productivity Among Farm Households.

Variable	2010/2011	2012/2013	2015/2016	2018/2019	Pooled
Total value of Output in Real Naira Value	263,298.64	173,327.17	119,512.02	115,977.65	168,028.87
Average Farm Size in Ha	3.49	2.69	0.95	1.11	2.06
Productivity in Real Naira value of output per ha	75,443.74	64,433.89	125,802.12	104,484.37	92,541.03
Mandays of Labour	183.41	128.96	208.87	146.35	166.89

Source: Computed using the 4 waves of the Nigeria GHS panel data.

4.3 Effects of Petroleum Products' Consumption on Agricultural Productivity.

In this sub-section, the discussion concentrates on the effects of consumption of petroleum products on agricultural productivity. Table4.3presents the estimated results where productivity variable was proxied by the real value of agricultural output per hectare. The variable of interest which is cost of petroleum fuels have negative effect on productivity of farm household but the effect was not statistically significant. This may be attributed to the fact that most smallholder farmers do not own farm machineries but hire from private owners to carry out farm operations, hence the cost of petroleum fuels for powering the machineries owned by private service provider may not be accurately reported by the farm households. In this case it is difficult to estimate accurately cost of the petroleum fuels indirectly consumed through hiring of machinery by the farmers.

Further, an increase in the use of farm machinery positively and significantly affects the productivity among the farm households. The effect on productivity per hectare is statistically significant at 10 per cent level or less. The estimates of the effects of the use of farm machinery on the productivity is 0.11 suggesting that a one per cent increase in the use of farm machinery will induce 0.1 per cent increase in productivity among the farm households. The result is consistent with other findings such as Amare et al 2016, Stephen Hamilton et al, 2020 and Peeyush Soni et al 2018. It was established by these earlier researchers that mechanisation reduces human drudgery, ensures timeliness of farm related activities and increases farm output in terms of productivity.

Farm households may supplement the use of labour with some form of mechanisation particularly for land preparation. Regarding labour input use, the same table 4.3 shows that mandays of labour had a positive and significant effect on productivity. This is plausible because agricultural production by smallholders in the country rely more on human labour particularly during planting and harvesting activities.

Table 4.3:Estimated Effects of Petroleum Products Consumption on Agricultural Productivity.

Independent Variables.	Dependent Variable: Log of Real Value of Output per hectare.			
	Coefficient	Standard Error	Marginal effect	p-value
Real Cost of Petroleum Fuels	-7.566E-08	4.37e-06		0.98
Quantity of fertilizer	6.86e-07	4.12e-07		0.34
Real Cost of agrochemicals	1.34e-06	2.21e-06		0.54
Farm machinery Use	0.106***	0.038	0.111	0.007
Mandays of Labour	4.76e-06**	2.11e-06	4.16e-06	0.040
Area planted	0.635***	0.080	0.712	0.000
Years of education	-0.004	0.003		0.270
Access to extension	0.078	0.052		0.146
Access to remittances	-0.124**	0.051	-0.116	0.014
Access to credit	0.115*** (0.0354)	0.035	0.122	0.001
Age of household head	0.003* (0.001)	0.001	0.002	0.056
Household size	0.015***	0.005	0.014	0.003
Constant	4.972	0.081		0.000
Diagnostic Statistics				
Wald Chi2 = 58.68				
Prob > Chi2 = 0.0000				
R-sq. =0.71				
Number of observation =2084				

Source: Computed using the 4 waves of the Nigeria GHS panel data

Moreover, among the household characteristics, the size of household significantly affects productivity per hectare. The effect of household size on productivity of land is positive and statistically significant at 5 per cent level. The magnitude of the effect is 0.01 implying that one percent increase in size of household will induce 0.01 per cent increase in land productivity. This shows the importance of family labour in agricultural production in the rural sector. With regard to the age of household head, the effect on agricultural productivity is positive and significant at a 10 percent level. The magnitude of the effect is 0.002 indicating that a one per cent increase in the age of household head will lead to 0.002per cent increase in land productivity. Credit access has a significant and positive effect on productivity per hectare as expected. The magnitude of the effect is 0.122 meaning that a one per cent increase in getting access to credit by farmers will induce 0.12 per cent increase in productivity per hectare. This means that access to credit will improve the value of crop output per hectare. Credit access among rural farm households may provide capital to acquire productive inputs like fertilizer, farm equipment, land, and wage payment. It could provide the means for many farmers to adjust their operations to keep up with the constant changes and by doing so, to improve their operations.

This is consistent with the earlier finding that farmers with credit access will be able to invest on high productivity technology such as application of farm machinery to improve their productivity. (Awotide et al 2015). Quantity of fertilizer has positive but no significant effect on productivity. Access to remittance has a negative and significant effect on productivity. This is contrary to expectation. This could be due to the fact that inflow of remittance received by a farmer may not be invested on agricultural production. Such inflows could create potential for such farmer to disengage from active agricultural practice thus crowding out investment in agriculture which may ultimately contribute to reduction in productivity.

V. Policy Recommendation and Conclusion.

On the basis of the findings of the study, in the short-run, government should strengthen effective linkage of smallholder farmers to agro-service centers through efficient extension system for effective, efficient and timely use of farm machinery and petroleum fuels for farm mechanization services. This will equally ensure effective use of other improved agricultural inputs derived from petroleum at affordable cost.

In the long run, technology development and research should give priority attention to generate alternative energy-powered machinery and implement as best replacement for farm machinery and implements presently using petroleum fuels. This will reduce the cost of petroleum fuels consumed to improve agricultural productivity.

Government should give incentives to private investors to encourage establishing agroindustry for production of farm machinery and spare parts so as to provide easy access to spare parts within the country at affordable cost for maintenance of farm machinery and their effective use by the farmers.

Delivery of affordable credit to rural farm households is crucial to improving agricultural productivity. This should be prioritized to reach farmers and meet timeliness of operations so as to encourage use of improved and high productivity technology that would raise the agricultural productivity and income among the rural farm households.

In conclusion, therefore,policy modification should focus on strengthening the agricultural institution capacity for efficient management and implementation of agricultural mechanisation in the present National Agricultural Technology and innovation plan 2021-2025 within the Medium Term National Development Plan. In the short term, increased access to farm machinery that rely on the use of petroleum fuels should be packaged with agricultural credit at affordable interest rate and should be well targeted to reach the rural farm households on time to meet farm operations during the planting season. This is very vital to improve agricultural productivity and income of rural farm households in Nigeria.

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