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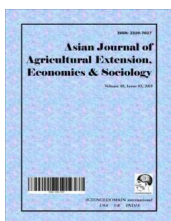
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## Determinants of Rice Yield in Northern Region of Ghana, the Role of Policy

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### Authors' contributions

*This research is a collaborative work coordinated by the corresponding author. Author MT designed the study and wrote the protocol. The background and the literature were written by author AFA. Authors MT and AI wrote the methodology and did the analysis. All authors read and approved the final manuscript.*

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### ABSTRACT

The paper estimates factors responsible for the variation of rice yield in Northern region of Ghana. A multivariate empirical regression model was used to determine the parameters of the internal and external factors that influence rice yield. The results from the double logarithmic regression model indicate that yield increased with producer price of rice and labour availability because of improvement in purchasing power and labour efficiency in farming activities. It was decreased with increasing harvested area and price of fertilizer due to fertility inadequacy in application and also increased with a rise in producer price of maize because of a shift in resource allocation in favour of maize production. It is important for government to improve farmers' access to fertilizer and credit. This would increase fertilizer application on farms and strengthen the purchasing power of farmers to boost local rice production. The regressors explain about 77.24% of the total variation in rice

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yields. This suggests that, expansion of cultivated field should be accompanied by intensification measures to help mitigate the adverse impact from sole expansion of area harvested. The combination of the various factors in improving rice yield in Northern region of Ghana should be the main focus of stakeholders in agricultural development and not the mere thinking of expansion of cultivated area.

**Keywords:** Northern region; rice yield; double logarithmic; fertilizer subsidy; credit access; input prices.

## 1. INTRODUCTION

Like many West African nations, cash crops and many staple crops in Ghana are less than their ecological potential level, at the same time, domestic and international demand for such crops are at a faster pace [1,2]. There is a wide gap between demand for local rice and its production in Ghana as a result of low yield. This is complemented by poor quality and irregular supply resulting from low yields. The excess in demand is bridged yearly through importation which is costly. The huge import has an inverse impact on the foreign exchange of the country and consequently results to pressure and unfavourable condition on domestic producers; this serves as a disincentive to them as most of them incurred loss in the production process [3]. Ghana is presently only about 30% self-sufficient in rice production, producing only about 150,000MT compared to a prevailing consumption requirement of about 700,000MT [4]. To meet the supply deficit, Ghana imports about 70% of its rice consumption requirement from Asia viz. China, Thailand and Vietnam, and the USA.

In improving the domestic rice industry, effort should gear toward an increased production using both pricing and non-pricing motivation mechanisms-offering high prices to domestic producers and restriction of trade through the imposition of specific and *ad valorem* tariffs as well as standards. In restricting trade, the domestic rice industry is affected in different directions; firstly, on the positive side domestic rice producer will benefit from reduction in imported rice due to rise in cost of importation. Inversely, purchase of imported production inputs at higher prices because of the country over dependence of country on imported raw materials such as fertilizer, tractors and pesticides. Because of the restriction of trade, many inputs (fixed and variable inputs) of production supply fluctuate for the period affecting domestic production of rice negatively. Ignoring the significant effects of inputs supply changes of rice in the domestic level will critical

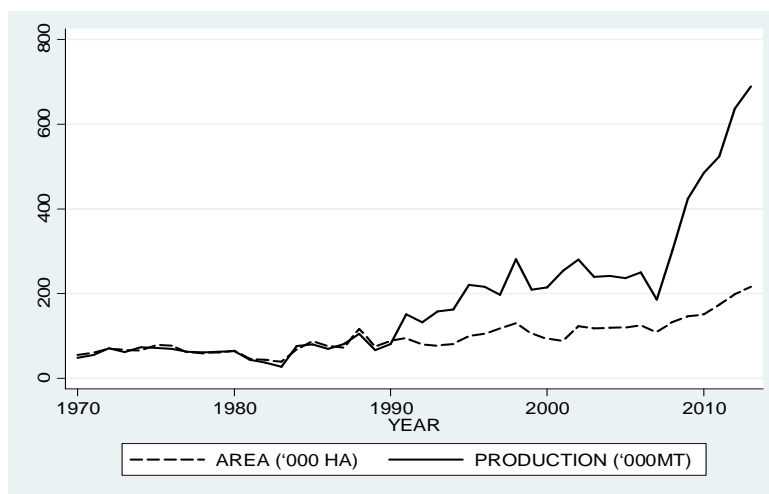
diminish the progress level of rice industry in Ghana [5].

Closing the demand and supply differences in Ghana and comparing domestic production with imported commodity of the same kind attracts the attention of many researchers including that of [5-7] who advised for the adaption of appropriate remedies to supplement increase area under cultivation with an intended aim of increase yields by at least 50%. Such remedies should be critical to couple with the important measures in related fields to improve rice production. The trend in rice production in Ghana over the years has been influenced by changes in both the area cultivated and productivity. Below, in Fig. 1, is the trend over the period 1970 to 2012:

During the seventies, rice production was relatively stable with a peak of 73.2MT in 1974. In the early eighties, production dropped steeply but from 1984, production increased reaching a peak of 689.2MT in 2012. The increase is attributed to increase in area of cultivation and the favourable rainfall patterns as well as the 2008 fertilizer subsidy programme, the Block Farm programme of 2009 which are also contemplated in the Ghana Rice Strategy [2].

In Northern region, rice production has been driven mostly by expansion in harvested area [8] with annual increases in yield characterised by stagnation. This called for many interventions to improve the production of rice in the region. The rice investment opportunity project undertaken by the Millennium Development Authority (MIDA), Coalition for Africa Rice Development (CARD) and the Japan International Cooperation Agency (JICA) dwelled much on the improved rice yield based on land increment and easy access to land in the region.

However, forecasted population growth, joint by infrastructural improvement and urbanization years to come [9], would be a symptoms of much pressure on available natural resources especially, land which has alternative uses to the



**Fig. 1. Areas and production of rice in Ghana 1970 – 2012**

Source: Author's plots using MOFA-Ghana data (1970 to 2012)

detriment of cultivation of both food and cash crops. The situation could be unfavourable on the welfare and poverty level of the people as it can lead to food insecurity. Though, the objectives are improvement in food security and the eradication of poverty in Ghana. The inverse impact of such situation could be reduced by increasing the farmers' productivity in the fields or cultivated area today, would be a step towards meeting tomorrow's demand. To help improve future policy decisions, this study aims at assessing factors that are responsible for the increase in the yield of rice in Northern Region of Ghana. The study takes account of both internal and external factors for the period 2000-2014 and identifies sectors worthy of investing.

## 2. LITERATURE REVIEW

### 2.1 Concept of Yield

Yield gap is the difference between maximum attainable yield and actual yield obtained by farmers. Maximum attainable yield refers to the highest yield that could be reached by a crop in a given environment [10], alternatively, yield gap is the estimates from crop models that assume perfect management or the highest yields at Agricultural Research Stations or farmers' fields [11]. [12,13] reported that, biophysical factors, socio-economic factors and institutional or political aspects that affect yield gaps cannot be exploited, but *gaps* mainly due to suboptimal crop management practices can be bridged by deploying more efficient research and extension delivery that are *exploitable (manageable)*.

Generally, critical assessment of the different production ecologies in Ghana indicates that there is a wide gap in rice yields that can be exploited to enhance rice production. This, together with expansion in area under cultivation could help boost overall production levels in the country. Factors that contribute to low yields need to be identified and analysed through yield gap survey (YGS) carried out in the production ecologies [14] and Northern region is not exceptional.

According to the Ministry of Food and Agriculture (2015) Statistics, Research and Information Directorate (SRID) [4], Northern region has five months of food insecurity in rice crop, though, it has abundant agricultural and natural resources. Majority of the crops produced in Northern region of Ghana has estimated yield which is less than the potential climatic yield. According to the Ministry of Food and Agriculture [2], facts and figures (2012), the yield of rice are less than their climatic potential. Comparing the achievable yields of 7.0 Mt/ha, 3.0 Mt/ha, 15 Mt/ha and 17 Mt/ha respectively for maize, millet, yam and Cassava to the potential yield of 1.8 Mt/ha, 1.8 Mt/ha, 12.5 Mt/ha and 13.3 Mt/ha respectively indicates less yield for these crops. At a production yield capacity of 7.2 Mt/ha for rice in terms of its climate, the region observed 2.61 Mt/ha in 2009, 3.0 Mt/ha in 2010, 2.33 Mt/ha in 2011 and 2.36 Mt/ha in 2012. This indicates that, Northern region by the 2010 estimate met only 42% of achievable yield and the year 2012 experienced achievable yields of about 33% of the climatic capacity.

Yield gap was computed by employing the planning gap formula asserted by [15], Yield gap is computed by subtraction actual yield / Climatic Potential Yield from a whole (1).

The decision rule is that, a value equals to zero suggests that the unit of respondent is on the production frontier while a value equals one indicating no productivity. The far away the yield gap to zero, the worst. Analysis of the yield gap line indicates that Northern region has a gap of 49% as at 2013 [13], the region could improve the yield level of rice if the necessary measures are put in place.

## 2.2 Determinants of Yield

Supply of rice has two inlets- domestic and foreign (imported rice). The domestic production depends largely on both internal and external factors common called pricing and non-pricing factors in market base. According to [16-18], rice production decision by producer of rice in the principles of economic affected by pricing factors such as producers' price of rice, producers' price of substitute field crops like maize, world price of rice and maize and prices of fertilizer which has critical indirect impact on producers. Also, non-price factors affects farmers decision such as irrigation, investment in research and development (R \$ D), extension services, capital and credit access, favourable agro-climatic conditions, development of rural infrastructure, abundant agricultural labour supply, area of land cultivated and income status of rice farmers.

Dercon [19] Asserts that prices are the most influential factors through which appropriate economic policies are anticipated to affect agricultural variables such as quantity of output, supply direction, exports and income levels of farmers. In analysing supply reaction to fluctuating rice prices is an important factor in examining the effects of a rising liberalised democratic economy. Whereas according to [20] the chances of improving domestic rice industry depends large on the degree of biophysical, socioeconomic and policy factors, [21] differentiate three major alternatives for increasing rice production: increase in harvested area, increase in cropping intensity and a rise in yield (produce per unit area). [22] and [23] advised that a changes in acreage under cultivation in an economic is equivalent to the amount of supply response to that change and that estimates from supply reaction studies are fair reflection of acreage reaction of a given

commodity. Opposite to their suggestion then came [24]. [24] Asserted that, a direct reaction from acreage response models will indicate positively on quantity only when factors that are jointly used in production are employed such as fertilizer, high yielding varieties, farm chemicals, improved cropping techniques and good farm management approaches. Examining the changing structure, conduct and performance of world rice market, [25] suggested that, as long as increased or stable production of rice varied/depend on irrigation, improved varieties and acquisition of fertilizer due to affordability, free entry of market by major foreign traders and the role of government in engaging in an opened trade of rice impact significantly on domestic rice production.

Rice production depends largely on environmental factors which are the most critical among the several factors influencing output. Rice yield depends on maximum combination of inputs to achieve a remarkable level. The inputs are not limited to the familiar production inputs but include distinguish environmental factors provided by nature. The unique features of the environment include: rainfall characteristics which entails duration and intensity, relative humidity and temperature which constitutes factors responsible for the variation of rice yield. Some of the factors have direct effect whilst others have an inverse relationship with rice yield [26].

## 3. RESEARCH METHODOLOGY

### 3.1 Data Set

The study used yearly average yield of rice per hectare, crop area of rice in hectares, average price of rice in Ghanaian cedi and average price of maize as a closer substitute in Ghanaian cedi, average price of fertilizer in Ghanaian cedi and agricultural labour force in persons in Northern region of Ghana for the analysis. The data span the period of 1970 to 2012. Information on all the variables is sought from the Ministry of Food and Agricultural Statistics, Research and Information Directorate (SRID). Data on agricultural labour force is confirmed by the Ghanaian Statistical Data Centre. All prices are converted from an old currency of cedi to the new currency of Ghanaian cedi (using GH¢1=¢10,000) before the analysis is done. All variables are also converted to natural logarithm before the estimation of the parameters using the double logarithmic regression model.

The data covers the period 1970 – 2012. The variables are selected on the basis of availability of a continuous time series data. Though, Supply of rice as perceived by previous researchers including [8,24,27], is influenced by many critical variables besides those specified in the table above. Such variables include the use of fertilizer, farmer's knowledge and experience, credit access and weather related variables such as temperature and rainfall. However, the research employed mean regional level data from relevant institutions. Acquisition of data on farm-level related variables such as access of farmers to credit and farmers knowledge levels were some of the constraints this research faced. In addition, getting a reliable and well documented information or data on time series and the study area was a challenged. Precipitation and temperature which are relevant in estimating yield of rice were not included in the analysis, hence, no results, as time series data on these variable are limited in supply at the relevant institutions.

### 3.2 Empirical Model

The research estimates both internal and external factors determining rice yield in Northern region of Ghana based on the modified multivariate empirical regression model as stated below:

$$\ln YLD_t = \beta_0 + \beta_1 \ln PR_{t-1} + \beta_2 \ln PM_{t-1} + \beta_3 \ln CRA_{t-1} + \beta_4 \ln PF_{t-2} + \beta_5 \ln AL_{t-1} + \varepsilon_t$$

Where:

YLD = Average yield of rice (Mt/ha)  
 PR<sub>t-1</sub> = Lagged average price of rice (GH¢)  
 PM<sub>t-1</sub> = Lagged average price of maize (GH¢)  
 CRA<sub>t-1</sub> = Lagged crop (rice) area harvested (000 ha)  
 PF<sub>t-2</sub> = Lagged average price of fertilizer (GH¢)  
 AL<sub>t-1</sub> = Lagged agriculture labour force (000 persons)

The above model was employed due to the simplicity in the interpretation of the parameters and the data meeting the OLS criteria. The model was subjected to a diagnostic test. The double logarithmic results were tested for multicollinearity, serial correlation and normality of the model. The model was tested for normality using Jarque-Bera test to ascertain the nature of the distribution of the residuals. The present or absent of multicollinearity was verified with the help of Variance Inflation Factor and the

Breusch-Godfrey serial correlation LM test. Q-stat was employed to evaluate existence or other wise of the first and second order serial correlation in the residuals and homoscedasticity/heteroscedasticity in the residual series was verified using ARCH test. Lastly, the value of R-squared adjusted was used to determine the goodness of fit of the model.

Estimating the model above led to the identification of factors that significantly affect rice yield in the study area after subjecting the series in to stationarity test to know the order of integration of the individual series. The variable series are tested for integration using Augmented Dickey-Fuller (ADF), Philip Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. Both the ADF and PP test carry out to test the null hypothesis of non-stationarity or there is unit root against the alternative of stationarity or there is no unit root. However, the KPSS test is the opposite. It tests the null hypothesis of stationarity against the alternative of non-stationarity. Using Stata 11.0 and JMuLTi indicate the results show in Table 2.

The results of the ADF and PP tests, considering the suggested lag lengths, show that at the 1%,significance levels with critical values of - 4.78, the null hypothesis of unit root is not rejected at level. This means, the series is non-stationary at level. Inversely, the null hypothesis is rejected in all cases after taking a first difference of all series and testing for stationarity. The KPSS results largely confirm those of the ADF and PP test. By this test we strongly reject the null hypothesis of no unit roots (i.e. the series is stationary) in the level of the series in all cases, but cannot reject the null hypothesis at the first difference of the series at the 1%. Therefore, the series under the study are first difference stationary processes i.e. they have unit root or are I (1).

## 4. RESULTS AND DISCUSSION

### 4.1 Descriptive Statistics

Table 1 shows the means, minimum, maximum and the standard deviations values of the continuous variables used in the yield respond model. It is shown in the table that the maximum and the minimum average yield of rice in Northern region amount are 3.0 Mt/ha and 1.2 Mt/ha respectively. Averagely, the region experience 2.16 Mt/ha yield between the period 1970 to year 2012 leading to 70% opportunity

**Table 1. Summary statistics of variables**

Variables	Observation	Mean	Minimum	Maximum	Standard Deviation
Yield	42	2.16	1.20	3.0	1.4
Area	42	33,870	21,540	63,930	2,880
Price of rice	42	28	11	53	22
Price of maize	42	27	13	47	14
Price of fertilizer	42	87	34	160	26
Labour	42	11,876	7,789	56,890	3,864

Source: Authors' computations

**Table 2. Unit root test of variables (Augmented Dickey-Fuller, Phillips-Perron tests and Kwiatkowski-Phillips-Schmidt-Shin)**

Variables	Level			First difference		
	ADF test	PP test	KPSS test	ADF test	PP test	KPSS test
lnYLD	-2.176	-2.331	3.4670***	-5.123***	-7.825***	0.0949
lnPR	-2.123	-2.672	2.3074***	-8.433***	-10.597***	0.4333
lnPM	-1.962	-1.226	2.8522***	-7.668***	-9.478***	0.0776
lnCRA	-2.093	-2.006	2.6793***	-7.425***	-11.610***	0.0241
lnPF	-1.976	-2.618	1.2267***	-6.407***	-6.969***	0.0408
lnAL	-1.84	-2.393	1.9799***	-9.984***	-5.230***	0.2877
1% Critical Value	-4.780	-4.780	0.6550			

Source: Authors' computations

Note: the asterisk \*\*\* denotes 99 percent confidence level for critical value of 0.01

improvement as the climatic potential for rice production is 7.2 Mt/ha in the region. Also, the Minimum and maximum prices of rice to producers at the working period are GH¢11 and GH¢53, respectively. This seems to suggest that, rice farmers get price incentive than maize farmers as maize farmers have the highest minimum price of GH¢13 at the same time have the lowest maximum price of GH¢47.

#### 4.2 Determinants of Rice Yield

Table 3 shows the regression results of double logarithmic model for rice yield and the output of the diagnostic test. In testing the normality of the model within the distribution of the residuals using the Jarque-Bera test leads to a less than the critical value, this means that, the residual series was normally distributed. Both the LM and the Q-stat test values of the Breusch-Godfrey serial correlation has rejected the null hypothesis of the present serial correlation in the residuals indicating the absence of the first and second order serial correlation, the ARCH test also rejected the null hypothesis of no homoscedastic among the residual series. The Variance Inflation Factor (VIF) mean value of 1.36 is less than 10 implying that there is no statistical significant multicollinearity among the regressors. It is also evidence that 77.24% variations in rice yield (regressand) are explained by the regressors as

the adjusted R-Squared is 0.7724. The F-statistic (42.36) is significant at 1% implies, the regressors (explanatory variables) has a joint significant impact on the yield of rice in Northern region of Ghana.

From Table 3, all the explanatory variables – lagged price of rice that rice farmers are likely to received, lagged price of maize farmers are likely to received, lagged land area in hectares used in cultivating rice in the region, lagged price of fertilizer as a major input for rice and lagged human effort available and willing to part take in the cultivation of rice have significant effects on the yield of rice in Northern region of Ghana. Also, the a priori signs of all the variables are met.

From Table 3 it was found that, producer price of rice is statistically significant at 0.01 as the probability value (0.000) is far less than 1% and exhibits the right a priori expectation. The coefficient 0.2795 implies, when farm gate price of rice increase by one percent, it will lead to a 27.95% increase in the yield of rice. This increase is statistically significant at 1% level. The fact is that, there is a direct relationship between farm gate price of rice and the farmers' financial status level, in that, the financial base of domestic rice farmers increase when farm gate price of rice rise. This gave the farmers an

important opportunity to satisfy both their short and long-run variable production expenditure such as purchase of improved seed, insecticides and pesticides among others as well as acquisition of other fixed assets (tractors, combined harvesters and spraying machines) that contribute to the improvement of rice yield.

On the contrary, farm gate maize price has a negative relationship with yield of rice as a competitive commodity. A fall in the price of maize price at the farm gate by one percent will induce yield of rice to shut up by 23.07%. The co-efficient is significant at the 99% confident level. The increase in the yield of rice may be attributed to a shift in production resource from maize to it substitute commodity as a result of the disincentive at the maize market. As it is an economic principle, a reduction in the price of a competitive or substitute field crop such as maize influences producers to transfer important means from a less opportunity area to an optimum profit oriented field like the production of rice. *Ceteris paribus*, every entrepreneur aims at maximizing profit which farmers are not exceptional, as a rationale entrepreneurs, farmers usual invest their production capacity on ventures (crops) that yield the highest profit using the theory of comparative advantage – comparing two substitutes crops based on their earnings. The benefit that accrued to farmers in their activities is the main source of income for their livelihood and the profit ploughed back is a way of sustaining their investment. This will enable them continue the cultivation and cropping activities in the years to come. The shift in resources

allocation from the production of rice to its counterpart crop is due to similarity in functions both in investment ground and survival of the farmer's family.

Cropping area for rice is statistically significant and conforms to the a priori expected sign, as it is a notion that an increase or expansion in the farm land of a farmer for cultivation will lead to an increase in production and yield. Based on the results in Table 3, the coefficient for harvested area was 0.369856 having a negative sign with a probability of 0.000 which makes it to be significant at 1% level. This indicates that, when a farmer increase his or her field of rice by one percent, it will leads to 37% reduction of rice yield. It was reported that most of the lands used for the cultivation of rice losses their fertility and rice farmers in the region are deep in to the income poverty water making it difficult purchase fertilizer to improve the fertility level of the soil artificially. It is observed and reported that, currently, the region experienced an increase the output of rice as a results of the expansion in harvested or cropped area rather than the adaption of modern technology to improve yield [8], this research confirmed the report of Ministry of Food and Agriculture as the findings of this research indicates a negative relationship between cropped area and rice yield, thus an increase in area farmed for rice leads to a low nutrients – crops ratio, in that, the available nutrients in the soil will not be sufficient for the utilisation of the grown crops and farmers in the region do not apply enough fertilizer in their production to improve the fertility of the soil either

**Table 3. Results of double logarithmic model for rice yield**

Variables	Coefficients (Elasticity)	Standard error	t-statistic	Probability	A priori expectation
Cons	-3.702345	0.488521	-2.64	0.038**	
LnPR	0.279476	0.067545	1.26	0.000***	+
LnPM	-0.230765	0.128345	-1.18	0.003***	-
LnCRA	-0.369856	0.076462	-1.63	0.000***	-
LnPF	-0.442737	0.765546	-2.17	0.041**	-
LnAL	0.895435	0.032455	1.08	0.000***	+
Observation	42	Jarque-Bera		1.035674(0.553412)	
Prob > F	0.0000	B-G LM: F-stat (1)		0.281763(0.473823)	
R-squared	0.7835	F-stat (2)		2.283778(0.112464)	
Adj R-squared	0.7724	Q-stat (1)		0.253554(0.335467)	
F-statistic	42.36	Q-stat (2)		2.187723(4.827374)	
Log Likelihood	23.65701	ARCH Test, F-stat		2.114532(0.152403)	
Sum squared resid.	0.895443	Akaike info criterion		-0.476429	
S .E. of regression	0.186495	Hannan-Quinn criter.		-0.565025	
Mean VIF	1.36				

\*\*\*P=0.01; \*\*P=0.05; \*P=0.1

Source: Authors' computations



due to the inaccessibility of credit as a results of lack of collateral security or insufficient knowledge on fertilizer application. The poor returns from farming activities-post harvest losses and poor transmission of price increments also affect farmers' purchasing power. Although, commercial and mechanised farmers may take advantage of an increasing area harvested in rice production to increase the outputs of rice crop, enjoy the advantage of large production (economies of scale) and reduce unemployment in the country, peasant and other categories of farmers that could not complement area expansion with important inputs of production to achieve the desire yield could lead to a negative influence as found in this research.

Price of fertilizer is unforgettable when it comes to modelling to identify the factors responsible for variation in the yield of rice. The coefficient is 0.442737 inversely and is statistically significant at 5% as the P-value is greater than 0.01 but less than 0.05. The coefficient (elasticity) suggests that a percentage rise in the price of fertilizer would leads to a fall in the yield or rice by 44.27% which is statistically significant at the 5% level. This means, there is 95% confidence that, when the price of fertilizer falls, rice yield will increase. Fertilizer is considered as one of the important independents variables in rice production function in enhancing productivity. As most of the domestic rice farmers are constrained financially, an increase in tariffs or a reduction of subsidy on fertilizer would leads to an increase in the prices of fertilizer, this would reduce the purchasing power of farmers the amount they have cannot buy the quantity it used to purchase. A reduction in the real income of the farmers would affect fertilizer application inversely leading to inadequate nutritional needs of the cultivated rice plants. The trickle down effects on low nutrition to rice plan is the automatic reduction of rice yield as observed in this research. It is reported by [28] in a USAID supported project 'Enabling Agriculture Trade' that, about 33% of fertilizer prices has been cut down through the use of subsidy by the government of Ghana by given coupons to farmers to purchase fertilizer. Still, farmers found it difficult to afford the remaining 67%. Price of fertilizer was rather seen to be at a high amount for farmers in the country and Northern region is the third poverty region in Ghana after Upper West and Upper East regions. This means, a unit rise in fertilizer price in the region has significant adverse effects on the production and for that matter rice output in the area.

Also, there is 0.99 confident that agricultural labour force is statistically significant in influencing variation in yield of rice in the study area. The direction of the influence is logical and makes economic sense in that, a change in labour force of farming has a positive impact on the yield of rice holding other factors constant (*ceteris paribus*). In the results arrived at, a rise in the availability of labour by one percent would results a 0.895% increase in yield of rice, there is a significant increase in rice yield due positive shift of agricultural labour at 1% level. The response of yield to an increase in the supply of labour for agricultural purposes is fairly elastic which suggest the numerous labours in Northern region encouraging the approach of labour intensive in rice production. A rise in the supply of labour over the demand of the same factor in the region would lead to a decrease in the existing wage leading to lower cost of accessing/employing labour or cheap labour in the study area for farmers. The willingness of available to work on the agricultural sector could call for redistribution of land for larger production of rice in the area. This will enable farmers' increase their yield as all farming activities and critical cultural practices such as sawing, weeding, pests control, fertilizer application and timely harvesting would carry out as schedule on plan. Motivating the youth to engage in agricultural activities especially, rice production by sensitizing them the benefits of the crop as both food and cash crop could improve the adoption of modern techniques of production to help improve and sustain rice yields in the country [27].

The coefficient of the intercept was significant at the 5% level with a value of 3.702345 negatively related to rice yield. This implies that, when all the variables/parameters co-efficient are zero, they would be a fall in yield with time significantly considering everything to be the same – no shifting cultivation, crop rotation and the application of any improve rice yield technology. The negative behaviour of the constant term by implication shows the need for the improvement of the fertility of the soil ensure sustainable yield as with time, the soil would loss most of the nutrients aid plan to give the optimum yield.

## 5. CONCLUSION AND POLICY RECOMMENDATION

The believed and practiced by farmers that output of rice increment depends largely on the expansion of cultivated land is a tradition in

Northern region of Ghana, though, there is abundant land in the region, the population is growing at a geometric rate and many stakeholder are calling for the improvement in the yield of rice in the area. This study used Ordinary Least Square (OLS) to estimate how much both internal and external factor influence the variation on rice yield.

The yield of rice in the study area found to change significantly with fluctuations in area cultivated for rice, prices of rice received by producers, prices of maize received by farmers, prices of fertilizer and human effort willing to engage their service in farming. 77.24% of the overall variations observed in rice yields were explained by the independents variables in the model. Yield has an increasing relationship with prices of rice producers received and labour availability. This could be attributed to improvement in the purchasing power of farmers and the ability of labour to use minimum resource to achieve the highest outputs in farming activities. Also, yield has an inverse relation with harvested area, thus, when harvested increases, yield would decrease and price of fertilizer due to fertility inadequacy in application and also increase with a rise in producer price of maize because of a shift in resource allocation in favour of maize production.

Government decision to reduce or remove fertilizer subsidy in the country is not in the right direction. Fertilizer usage by farmers in the sub-region is quoted by [29] to be quite low, resulting in low productivity of farmers' fields. Fixing the fertilizer subsidy at 33% by government with a purpose of improve fertilizer usage on farms to boost local rice production have proved quite futile as its usage is still reported to be low [28] and [30]. Among the factors reported to preclude farmers from accessing and/or using adequate amounts of fertilizer for their cropping are insufficient credit support for farmers and high lending rates by Commercial Banks [31]. In addition to this, most farmers in the major rice producing districts (Upper East, Upper West, Northern Region and Volta Region) are poor and are unable to meet the cost of fertilizing their fields in spite of the 33% subsidy [28]. Marketing of fertilizer is also concentrated in the southern parts of the country (relatively low rice producing regions), thereby increasing the challenge in accessing the input and cost of fertilizing rice farms in the major producing districts. This to a greater extent precludes the appropriate delivery and achievement of the goals for the fertilizer subsidy program.

Rice farmers' organizations (co-operative society) in the region should be strengthened to help improve negotiations on access of farmers to credit. Inversely, should efforts to reduce lending rates prove futile, the percentage of subsidy on fertilizer could be increased for the purpose of increasing fertilizer usage on rice farms in the country to help meet the 2018 rice sub-sector goals (doubling rice production and reducing imports by 50%) stated in the National Rice Development Strategy 2009.

Lastly, cultivated area expansion with vital intensification measures to help mitigate the adverse impact resulting from cultivated area expansion is a critical point in policy implementation. Measures should as well be put in place to ensure appropriate transmission of prices with the least distortion as such distortionary measures usually lead to increase in input prices through secondary effects. Emphasis should as well be placed on reducing labour shortages and drudgery by improved mechanization. The current fertilizer subsidy programme should be improved upon and measures should put in place to improve farmers' access to credit as it is critical in effective allocation of fertilizer to farmers for the improvement of rice yield.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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