Response of rice yields in Ghana: some prescriptions for future rice policy

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RESPONSE OF RICE YIELDS IN GHANA: SOME PRESCRIPTIONS FOR FUTURE RICE POLICY

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ABSTRACT

With local rice production lagging well behind demand as a result of low productivity of farmers' fields, this study analyzed the response of rice yields in Ghana to major internal and external factors which have direct and indirect effects on production and to producers. Yield of rice was found to increase with producer price of rice, irrigated area, labor availability and world price of rice to producer price of rice ratio. It however decreases with increases in harvested area and price of urea fertilizer due to fertility issues, producer price of maize due to influences from resource allocation, and with nominal rate of assistance due to secondary distortions on input prices. To increase and sustain rice yields, future rice policy measures should couple area expansion with vital intensification measures to help mitigate the adverse impact from sole expansion of area and should as well ensure appropriate transmission of prices with least distortion. Investment should be made towards the initiation and diffusion of low cost water control and irrigation systems across the country and vital measures be devised to reduce labor shortages. In improving the fertility of farmers' fields, the current fertilizer subsidy structure should be improved upon and measures put in place to improve farmers access to credit as this is a vital issue that needs addressing to ensure appropriate response of farmers to future price and non-price incentives

Keywords: *Yield response, rice planning, productivity, Ghana*

1.0 INTRODUCTION

Information about response of rice yields to changes in vital inputs of production allows for the devising and implementation of appropriate rice policy measures. Ghana is a nation whose Agricultural production is characterized by low productivity of farmers' fields. Like many other West African countries, yield of major staples and agricultural export commodities in Ghana are far below their climatic potential, yet demand for such commodities are ever on the increase domestically and internationally. Characterized by poor quality and irregular supply resulting from low yields, local rice production in Ghana has failed to catch up with the ever increasing domestic demand, thereby resulting in widening of the gap between demand and production. This gap in demand is been bridged annually with huge sums of money through imports. Such imports drain foreign exchange of the country and lead to intense and unbalanced competition on the part of local producers; majority of which observe negative returns in the process (FAO, 2006)

In pursuit of reviving the local rice industry by induction of increased production through price incentives and restriction measures reflected by imposed *ad valorem* tariffs and captured by the nominal rate of assistance, the local rice industry is affected in diverse ways; on the positive side through a likely gradual reduction in imports due to increased cost of importation, and on the adverse side through secondary effects on price of imported inputs of production due to the country's over dependence on imported inputs like fertilizer and pesticides. In the midst of these, several other fixed and variable inputs of production have undergone dramatic changes over the period, influencing local rice production in the process. Failure to capture the influence of such changes may preclude identification of vital prohibitions and boosters of rice production in Ghana

In bridging the supply gap between demand and domestic production, past research works including that of Olaf and Emmanuel (2009) and Aker *et al* (2011) have advised for implementation of policy measures that will help double the area under cultivation and increase yields by at least 50%. Such measures are to be coupled with investment in other vital areas. To help inform future rice policy decisions, this study assesses the yield response of rice to some selected internal and external factors for the period 1966-2009, as well as identifying areas worth investing in.

2.0 RICE PLANNING OF GHANA: YIELD GAP ANALYSIS

Speaking at the launch of a seminar organized by CGIAR Fund Office, Dr Robert Zeigler (Director General of the International Rice Research Institute (IRRI)) placed an advise that

“ Because of rapid population growth and diminished harvest due to climate change and other weather related stress, such as severe drought and floods, global demand for rice will outstrip supplies unless concerted action is taken now to boost yield growth and improve the management of water, land and other resources on which production depends”

This statement raises an alarm on risk and uncertainty in future supply of rice and the likely impacts that may have on welfare of both producers and consumers globally. Like many other West African countries, rice production in Ghana has been driven mostly by expansion in harvested area (MoFA, 2009) with annual increases in yield more or less stagnating. With anticipated rapid growth in population, urbanization and infrastructural development in the near future, there would be much pressure on available land for alternative uses at the expense of crop production. Such situation if observed could impact adversely on welfare and preclude the achievement of vital food security and poverty reduction goals. Effects of such incidences could however be mitigated by increasing the productivity of farmers’ fields today towards meeting demand on the morrow.

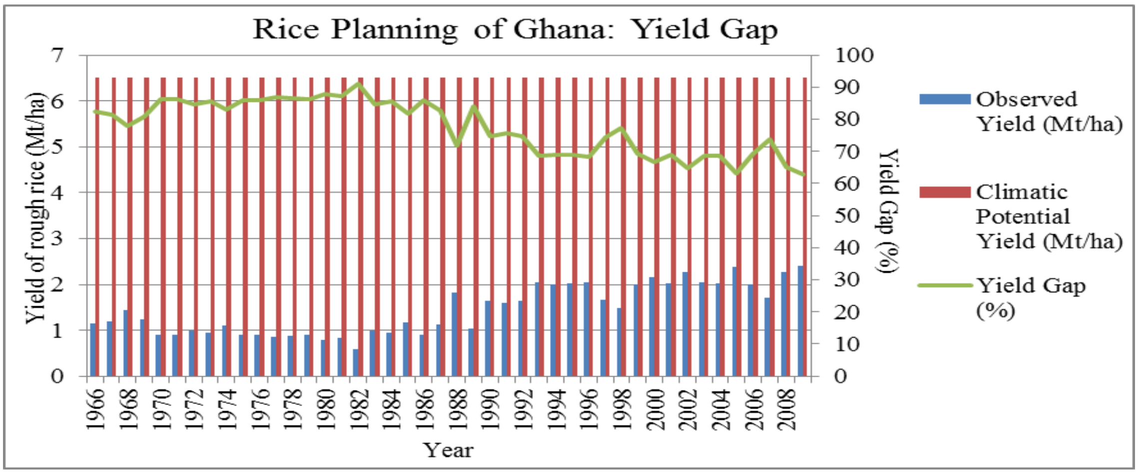
Although blessed with abundant agricultural and natural resources, yields of most of the crops produced in Ghana by estimates from the Ministry of Food and Agriculture (MoFA: Facts and Figures) are far below their climatic potential. With achievable yields of 6.0 Mt/ha, 2.0 Mt/ha, 1.0Mt/ha, 49Mt/ha and 72Mt/ha respectively for maize, millet, cocoa, yam and pineapple, 1.7 Mt/ha, 1.3 Mt/ha, 0.4 Mt/Ha, 15.3 Mt/ha and 50Mt/ha respectively were observed for these crops. Of a climatic potential of 6.5 Mt/ha for rice, the country observed 2.4Mt/ha in 2009, 2.73 Mt/ha in 2010, and 2.71Mt/ha in 2011 and 2012. This indicates that, Ghana by the 2009 estimate met only 38% of achievable yield, with the years between 2010 and 2012 witnessing observed yields of approximately 42% of the climatic potential.

The yield gap was calculated using the planning gap formula suggested by Licker *et al* (2010)

Yield gap = 1 – (Actual Yield / Climatic Potential Yield)

A value of zero indicates that the decision making unit is on the production frontier and a value of one indicates no productivity. The closer the yield gap (as reflected by the green line in fig. 1.0) is to zero, the better. By the yield gap line, Ghana as of 2009 (although 42% as of 2012) meet only 38% of achievable yield of rice. Measures could therefore be put in place to improve yield in the country through identification and addressing of appropriate influencers as enough room for improvement (62% as of 2009, and 58% as of 2012) still exists.

Figure 1.0 Yield Gap of rice for Ghana, 1966-2009



Source: Author's construct with data from IRRI (World Rice Statistic, FAO data)

3.0 LITERATURE REVIEW

Rice production decision of farmers in economic theory is influenced by both price and non-price factors. The common non-price factors identified in literature so far have been on irrigation, investment in research and development, extension services, access to capital and credit, agro-climatic conditions, rural infrastructure, agricultural labor availability, area of land cultivated and status of rice farmers (Bingxen and Shenggen (2009); Sachcharmarga and Williams (2004); Mythili (2008)). The main price factors identified as having influence on farmer's production decisions are producer price of rice, producer price of competitive field crops like maize, price of urea fertilizer, and world price of rice and maize with important indirect effects to producers (Molua (2010); Mulwanyi *et al* (2011)). Dercon (1993) suggested that prices are the general conduit through which economic policies are expected to affect agricultural variables such as output, supply, exports and income and that analyzing supply response to changing prices is a crucial element in assessing the effects of increasing openness of the economy.

Whereas the opportunities for developing rice production according to Molua (2008) depend to a large extent on biophysical, socioeconomic and policy factors, Defoer et al (2004) distinguished three major options for increasing rice production: area expansion, increase in cropping intensity and increase in yield (produce per unit area). Cummings (1975) and Holt (1999) advised that supply response is equivalent to the response of acreage under cultivation to changes in economic and non-economic factors and that estimates from acreage response studies are fair reflections of supply response of a given commodity. In contrast to their suggestion however, Molua (2010) advised that positive signals from acreage response models will reflect positively on output only on the employment of complementary factors of production such as fertilizer, high yielding varieties, farm chemicals, improved cropping techniques and better farm management methods.

In assessing the changing structure, conduct and performance of world rice market, Dawe (2004) also advised that, while increased production stability of rice may be due to factors like irrigation , pest and disease resistance of new and improved varieties, green revolution, access to cheaper fertilizer and the ease of entry of markets by major exporters, as well as the role of government in liberalizing international rice trade do impact significantly on the performance of domestic rice production

4.0 MODEL SPECIFICATION AND DATA

The current study estimates yield response of rice for Ghana based on the following equation:

$$YLD_t = \beta_0 + \beta_1 HARV_{t-1} + \beta_2 PPR_{t-1} + \beta_3 PPM_{t-1} + \beta_4 WPU_{t-1} + \beta_5\, IRA_{t-1} + \beta_6\, AL_{t-1} + B_7\, NRA_{t-2}$$

$$+ \beta_8\, (WPR/PPR)_t + \beta_9\, (WPCORN/PPM)_t$$

YLD_t – yield of rough rice (Mt/ha)

$HARV_{t-1}$ - lagged harvested rice area ('000' ha),
PPR_{t-1} - lagged nominal producer price of rice (Standard Local Currency Unit),
PPM_{t-1} - lagged nominal producer price of maize (Standard Local Currency Unit),
WPU_{t-1} - lagged price of urea fertilizer, world price as proxy for local price (US$/t fob)
IRA_{t-1} - one period lag of irrigated area, irrigated agricultural area as proxy ('000' ha)
AL_{t-1} - one period lag of labor availability, agricultural labor force as proxy ('000'persons)
NRA_{t-2} - two-period lag of nominal rate of assistance (%)
$(WPR/PPR)_t$ -world price of rice to local producer price of rice ratio
$(WPCORN/PPM)_t$-world price of corn to local producer price of maize ratio

Data on all the variables were collected from the IRRI website (World Rice Statistics) and the agricultural production database of the FAO (FAOSTAT) for the period 1966-2009. Nominal local rice and maize prices in Local Currency Units (LCU) were converted to Standard Local Units (SLC) using the FAO conversion Factor of 1GHS = 1000 GHC. World price of urea was used as a proxy for local price due to difficulty in getting time series data on local price of urea fertilizer and due to the high dependence of Ghana on imported fertilizer and other inputs for production. Irrigated agricultural area was used as a proxy for irrigated rice area, due to lack of appropriately documented time series data on area of rice under irrigation, and due to the greater share of rice in formal public irrigation schemes in the country. Agricultural labor force is used as a proxy for labor availability because it is a fair reflection of labor per unit area and gives appropriate signals on the increasing or decreasing availability of labor for cropping and other productive activities. The price ratios are to help capture the indirect effects of world prices of rice and maize on local supply (yield) of rice.

Prior to estimation of the specified regression (with all variables in the log form except nominal rate of assistance (NRA)), the whole set of data was verified to ascertain the order of integration of the individual series, as this is a vital step in the data generation process and choice of estimator.

5.0 RESULTS

Verification of the data set (with all variables in log except NRA) as sourced through the Augmented Dickey-Fuller and Phillips-Perron tests showed that all the variables are non-stationary at level, but become stationary at first difference. Having observed no *I*(2) variable(s) in the data set, the regression equation was estimated using the Ordinary Least Squares (OLS) estimator, followed by series of diagnostic tests to avoid spurious results.

Table 1.0 Unit root test of variables (Augmented Dickey-Fuller and Phillips-Perron tests)

	Level		First Difference	
Variables	ADF	PP	ADF	PP
YLD	-3.447409	-3.309861	-10.35932***	-11.39051***
HARV	-3.453404	-3.416014	-8.517481***	-8.991357***
PPR	-0.772423	-0.713302	-6.237591***	-6.232334***
PPM	-2.589135	-2.623278	-8.462565***	-8.588702***
WPU	-2.520567	-2.630823	-5.314694***	-5.631326***

IRA	-1.369490	-1.197824	-7.201714***	-7.232126***
AL	-1.662729	-1.697834	-6.245319***	-6.244984***
NRA	-3.403103	-3.389963	-6.746493***	-9.662176***
(WPR/PPR)	-0.878595	-1.206848	-4.588158***	-4.373476***
(WPCORN/PPM)	-2.675803	-2.665969	-7.643306***	-7.854622***
Critical value	-3.518090			

NB: 95 percent confidence level for critical value, ***1%

Diagnostic tests for serial correlation, normality, structural stability and misspecification of the functional form through a Reset test were applied, and the results show that the regression equation passed all the diagnostic tests. The insignificant value for the Reset test reflects appropriate specification of the regression equation. The Jarque-Bera test for ascertaining normality in the distribution of the residuals gave a value below the critical value, thus, implying that the residual series has a normal distribution. Both the Breusch-Godfrey serial correlation LM test and the Q-stat values indicated the absence of first and second order serial correlation in the residuals, with the ARCH test confirming a homoscedastic nature of the residual series.

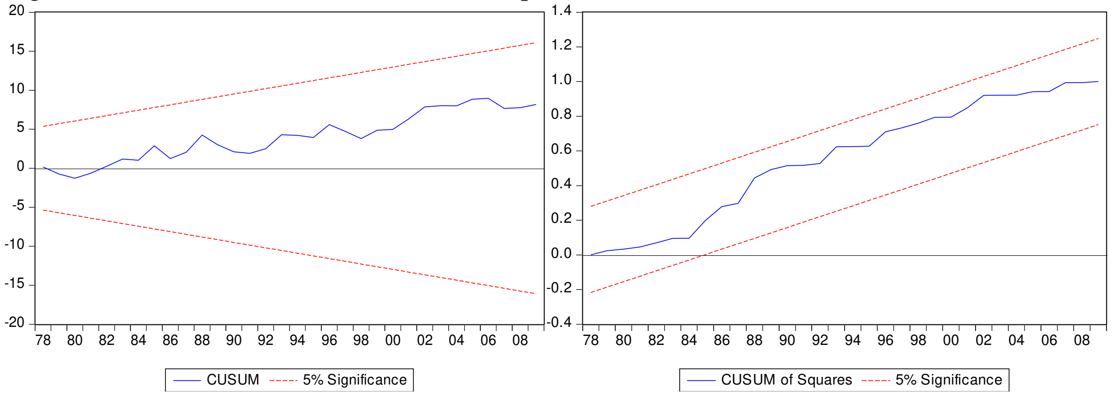
To affirm the reliability of the estimates (thus checking for spuriousness of the result), the residual series was tested for stationarity through the Augmented Dickey-Fuller test. The result showed that the residual series is stationary, with the ADF statistic being significant at the 1% level. In analyzing the stability of the estimated coefficients, the CUSUM and CUSUM of squares were applied, and the results showed that they remain within the 5% boundary, signaling an appropriately specified regression equation with stable coefficients.

Table 2.0 Estimates of yield response of rice for Ghana

Variables	Coefficients	t-statistic	
Intercept	-10.30665	-3.193080***	
Log $HARV_{t-1}$	-0.479713	-3.883248***	
Log PPR_{t-1}	0.391787	2.828497***	
Log PPM_{t-1}	-0.276550	-2.626904**	
Log WPU_{t-1}	-0.190170	-2.880209***	
Log IRA_{t-1}	0.708862	1.744726*	
Log AL_{t-1}	1.294133	3.493153***	
NRA_{t-2}	-0.131358	-2.247172**	
Log $(WPR/PPR)_t$	0.230408	2.302919**	
Log $(WPCORN/PPM)_t$	-0.094337	-1.011312	
Adj. R^2	0.836137	F-statistic	24.24546
Durbin-Watson Stat	2.206359	Prob (F-statistic)	0.000000
Jarque-Bera	0.476584(0.787972)	Log Likelihood	23.12018
B-G LM F-stat (1):	0.944823(0.3386)	Akaike info criterion	-0.624770
F-stat (2):	1.243609(0.3028)	Schwarz criterion	-0.211040
Q-stat (1):	1.0585(0.304)	Hannan-Quinn criter.	-0.473122
Q-stat (2):	2.0758(0.354)	Mean dependent var.	0.309781
ARCH Test, F-stat:	0.479386(0.4928)	S.D. dependent var.	0.394913
Rest Test :	0.639130(0.4301)	S.E of regression	0.159861
ADF of residual :	-7.683196***	Sum squared resid.	0.817775

***1%, ***5%, *10%

Figure 2.0 CUSUM and CUSUM of Squares Tests



In interpresting the result, the individual effects of the variables on yield of rice with the except of the world price of maize to local price of maize ratio were all found to be significant. Of the total variations in yield of rice observed in the country, a total of about 83.61% are explained by the variables in the specified equation for the current study.

Lagged harvested area of rice had a coefficient of -0.4797, and this was significant at the 1% level. This indicates that a unit increase in area harvested of rice leads to a 0.4797% decrease in yield. Rice farmers in Ghana are reported to be mostly financially constrained and majority of the fields are reported to be low in fertility. With current output of rice in the country reported to be driven by increases in harvested area rather than by yield (MoFA, 2009), an increase in area harvested leads to intense competition for the limited nutrients available in the soil, as most farmers either do not patronize fertilizer in their production or use inadequate amounts due to financial problems, resulting from lack of access to credit (with high interest rates on those available) and to inadequate returns due to the poor transmission of price increments. Although increasing area harvested may pave room for mechanizing rice production, as well as making efficient use of available labor and exploiting economies of scale, inability of farmers to complement area expansion with vital inputs of production could result in the adverse effect observed for the current study

A unit increase in the farm gate price of rice leads to a 0.3918% increase in yield, and this increase is significant at the 1% level. An increase in the farm gate price of rice increases the financial base of local rice farmers and offers them an opportunity to meet vital short and long-run production cost as well as acquiring other fixed assets vital for improving yields. Contrary to this however, a unit increase in the farm gate price of maize leads to a decrease of -0.2766% in yield, significant at the 5% level. This decrease is attributed to resource allocation decisions of farmers in times of price increments. Increase in the price of competitive field crop like maize leads to withdrawal of vital resources from the production of rice into the production of maize in pursuit of making higher profits. As rationale beings, farmers mostly allocate resources in favour of the most enticing area of production in order to sustain their families and ensure continuous investement in and sustenance of their cropping activities and outputs.

A unit increase in the price of urea fertilizer leads to a decrease of 0.1902% in yield and this decrease is significant at the 1% level. Fertilizer is regarded one of the very essential inputs in rice production for enhancing productivity. With most of the local rice farmers being financially constrained, an increase in the price of fertilizer would reduce their purchasing power on the amount they are able to access and purchase for their cropping. Inability to meet the nutritional needs of the rice plants through application of adequate amounts of fertilizer, may result in the obvious adverse effect observed for the current study. It is reported by Fintrac Inc (2012) in a USAID funded project 'Enabling Agriculture Trade' that the government of Ghana currently covers 33% of the price of fertilizer through subsidy on purchases, yet the remaining 67% is still regarded a high amount for the financially challenged farmers who depend mostly on rice production for subsistence, selling surpluses in the process.

Irrigated area had a coefficient of 0.7089, significant at the 10% level. This indicates that a unit increase in the supply of water leads to a 0.7089% increase in yield of rice. The significant increase in yield with increasing water supply, attests the importance of water in achievement of increasing and sustainable yields. Yields in the country have witnessed more or less stagnation in annual increases due to the over-dependence of rice production on rainfall, which consequently has resulted in a single cropping season in almost all the rice producing regions. The amount of yield observed annually has for over a long period been dictated by the amount and distribution of rain (normal, flood, or drought). Increasing the area irrigated could help reduce the adverse effects (risks) from the erratic patterns of rainfall and induce a doubling cropping season if made available at a lower cost to both the small-holder and large-holder producers.

A unit increase in labor availability leads to a 1.294% increase in yield of rice, and this increase is significant at the 1% level. This elastic response of yield to increasing availability of labor confirms the labor-intensive nature of rice production in Ghana. Increasing the labor available in the country by economic theory leads to lower cost of accessing/employing a hand to work on a farm. The ready availability of hands to work on the farm could induce an increase in area cultivated of rice and at the same time ensure timely undertaking of vital cultural practices like weed control, pesticide application, fertilizer application and timely harvesting. Increasing availability of labor (capturing a greater part of the youth) could as well catalyze the adoption of modern techniques of production to help improve and sustain yields in the country.

Intervention of the state, captured by the nominal rate of assistance is observed to have an adverse effect on yield of rice through secondary distortions in prices of inputs of production. Although the primary purpose of such assistance is to create a wedge between international and domestic prices of the commodity, unlike the effective rate of assistance, the nominal rate of assistance mostly fail to capture distortions in the prices of intermediate inputs of production, resulting in increases in the price of such inputs (most of which are vital to rice production). Distortions in prices of both output and inputs have several effects on production. Increases in the price of rice through tariffs imposed on imports are poorly transmitted based on the market structure and the subsequent increase in the price of inputs worsens the burden of farmers due to increased cost of production, thereby affecting farmer incentives. This effect could however be mitigated to a greater extent through devising and implementation of offsetting measures for majority of the imported inputs for production. This as well would come at a cost. A unit increase in the nominal rate of assistance led to a 0.131% decrease in yield and this was significant at the 5% level.

The world price of rice to local farm gate price of rice ratio had a coefficient of 0.2304, significant at the 5% level. This indicates that a 1% increase in this ratio leads to a 0.2304% increase in yield. The increase in yield with an increase in this ratio is attributed to a reduction in competition by virtue of increased cost of importation which subsequently leads to a decrease in the amount of rice imported into the country. A decrease in the amount imported reflects a likely increase in the share of local rice on the domestic market and an increase in profit to producers if major transmission, structural, financial and biophysical problems are appropriately addressed. With time, such increases could also stimulate production for exports if current limitations are attended to. The world price of corn to local farm gate price of maize ratio had a negative effect on yield, but this effect was not significant. The overall effect of all the variables as captured by the F-statistic was found to be highly significant

6.0 CONCLUSIONS AND RECOMMENDATIONS

Yield of rice in Ghana is observed to vary significantly with changes in area harvested of rice, producer price of rice, producer price of maize, price of urea fertilizer, irrigated area, availability of labor, nominal rate of assistance and world price of rice to local producer price of rice ratio. The effect of world price of corn to producer price of maize ratio was found to be insignificant. These variables explain about 83.62% of the total variations observed in yields of rice. Yield increases with producer price of rice, irrigated area, labor availability and the price ratio for rice. It decreases with increases in harvested area and price of urea (due to fertility issues), producer price of maize (due to influences from resource allocation in favor of maize production) and with nominal rate of assistance (due to secondary distortions on input prices, which consequently lead to increased cost of production).

To increase and sustain yields, future rice policy should couple area expansion with vital intensification measures to help mitigate the adverse impact from sole expansion of area. Measures should as well be put in place to ensure appropriate transmission of prices with least distortion as such distortions usually lead to increases in input prices through secondary effects. Investment should be made towards the initiation and diffusion of low cost water control and irrigation systems across the country and vital policy measures devised to reduce labor shortages. The current fertilizer subsidy structure should be improved upon and measure put in place to improve farmers access to credit as this is a vital issue that needs addressing to ensure appropriate response of farmers to future price and non-price incentives

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