Comparative advantage and factors affecting maize production in Northern Ghana: A Policy Analysis Matrix Study

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Abstract

Maize is one of the most important crops produced and consumed in Ghana, accounting for 58% of local cereal production. Increasing food prices worldwide and the gap between production and consumption of maize in recent years in Ghana present the country with growing import bills and higher prices for consumers. The purpose of this study was to analyze whether farmers in the northern sector of Ghana have a comparative advantage in the production of maize as import substitution. The effect impact of the fertilizer subsidy program on the yield itself and consequently on the private and social profitability has been tested. Fertilizer subsidy programs are one of the most popular policy programs in Africa. In the mid-90s many countries introduced them to increase crops yield.

Household survey data of the cropping season 2010 were collected and complemented with data from different institutions. We applied the Policy Analysis Matrix (PAM), to assess policy effects on production systems, and the Cobb-Douglas production function to identify factors affecting the output of each system. The results suggest that production systems with yields above the national average of 1.5 Mt/ha are profitable at private level and contribute to growth of the national economy. Farming systems producing below this threshold report negative social profits, implying that they do not use scarce resources efficiently in the production of maize and depend on government intervention. Policy implications are drown and, in conclusion, we consider essential to combine single policy tools and used in synergy to realize the full efficiency of each.

Keywords: Policy Analysis Matrix, Cobb-Douglas, comparative advantage, Ghana, maize

1 Introduction

Agriculture is an important sector in Ghana it accounts for about 20% of Ghana's Gross Domestic Product in 2014 (World Bank 2015) and employs more than half of the workforce, and has the potential to promote overall growth of the economy and have a positive impact on food security (FAO 2011). Maize is one of the most important crops produced and consumed in Ghana, accounting for more than 50% of local cereal production (ISSER 2014). However, the gap between production and consumption of maize in recent years in Ghana present the country with growing import bills and higher prices for consumers. In the northern compartment of the country, due to the geographical position on one hand and the harsh climatic conditions and on the other, low investments have been undertaken in the last decades which translated into poor infrastructure development and low access to institutional services. Nevertheless, small scale farmers are here producing a considerable share of the total maize consumed in the country. This rather difficult conditions prevailing in the north Ghana make this sector comparable to many other West African countries.

The purpose of this study was to analyze whether farmers in the northern sector of Ghana have a comparative advantage in the production of maize as import substitution under the current world prices and domestic policies. Input subsidies are one of the most popular policy programs in Africa, mainly after the success Malawian fertilizer success story between 2005 and 2007. The Ghanaian government subsidizes, since August 2008, the costs of the major inputs. The study aims to assess the impact of the fertilizer subsidy program on maize yield itself and consequently on the private and social profitability of maize production, in the more neglected area of the country.

Average maize yield is stable between 1.2 and 1.8 metric tons (Mt) per hectare (ha), where and achievable yield reaches 3 Mt/ha under rain fed conditions in Ghana. On-station and on-farm trials suggest that yield averages between 4 and 6 tons/hectare for maize are actually achievable in the country (MOFA/CRI/SARI 2005; various annual reports of the Crops Research Institute [CRI] and the Savannah Agricultural Research Institute [SARI] in Ragasa et al.2013). Agricultural production and especially maize yields below production potential are common phenomena in most African countries. Low yields generally happen because of too low input use and poor adoption of technologies (FAO 2005).

The Green Revolution in Asia demonstrated that a rapid growth is achievable in a relatively short period, if investments target the use and distribution of modern technologies. Until today, in Africa the use of modern technologies such as the use of fertilizer, high yielding varieties and irrigation is considerably low (Cudjoe et al. 2010; Breisinger et al. 2008).

Yield data from the FAO suggest that yield increase in Ghana was of about 1.1% per year and is ranking among the lowest in the world, even if compared with countries of similar conditions (Ragasa et al.2013). In 2010, the food production estimates recorded a marginal increase of 4% of cropped area and aaccording to MoFA, to take advantage of the subsidies program, farmers shifted their cultivation from root and tuber crops to maize and rice, since the commercial price is higher compared to the other cereals and tuber crops (MoFA 2010a).

The paper is organized as follows. Section 2 provides a description of the conceptual framework adopted, followed by the methodology in section 3. Section 4 presents the results and after the discussion in section 5, sets a few recommendation for strengthening the impact of the input policies currently in place, followed by concluding remarks in section 5.

2 Conceptual Framework

Small scale farmers (90%) dominate the food production scene in Ghana and own 2 hectares of land, the traditional shifting cultivation system is very common as land preparation practices (MoFA 2010a). This is happening, even though time is needed in which the field is allowed to rest between cultivations. Usually the seeds are obtained from the previous harvest and an intercropped cultivation system is preferred, partly to reduce the risk of total crop failure (Seini 2002).

Large farms and plantations are common for rubber; oil palm and coconut, to a lesser extend for food crops, such as rice, maize and pineapples. The crop farming system depends very much on soil fertility and the weather conditions, since only little chemicals are applied and irrigation systems are very rare (MoFA 2010a).

The Green Revolution in Asia demonstrated that a rapid growth is achievable in a relatively short period, if investments target the use and distribution of modern technologies. Agriculture can be seen as an engine. Its growth promotes the growth of all other sectors (Kuznets 1966). Until today, in Africa the use of modern technologies such as the use of fertilizer, high yielding varieties and irrigation is considerably low (Cudjoe et al. 2010; Breisinger et al. 2008).

The research analyses quantitative data from a household survey, in the first place to compute a farm budget on which we applied the Policy Analysis Matrix (PAM) to be able to assess the comparative advantage of maize production in northern Ghana and identify the factors which effectively influence maize yields and through the use of a the Cobb-Douglas production function.

The Policy Analysis Matrix approach was developed by Monke and Person (1989) to address three principal issues: First, most important for ministries of agriculture are farm policies to determine how agricultural prices affect farming profits. The second issue is the impact of policies on the economic efficiency or comparative advantage of the analysed system and how this pattern can be, eventually, changed by public investment. The third issue is related to the allocation of the future funds for agriculture research, with the main concern of increasing social profits by rising crop yields and reducing social cost (Monke & Pearson 1989)s.

A classical Cobb-Douglas (C-D) production function is employed to estimate the degree of influence of the inputs with respect to the agricultural output. The production function is determined by the resources available to the farmer. In agriculture continuous factors of production are land, labour and capital. Other factors such as fertilizer, rainfall, soil also play a role in the production of agricultural output.

The framework allows to assess whether the maize systems producing more and those producing less than the national average (1.5Mt/ha in the reference year 2010) are profitable at private and social prices (including family labor costs). Additionally, it enables to derive the factors that are directly related to yield increase.

3 Methodology

3.1 Policy analysis matrix

The survey used two-stage clustered sampling procedure. First, the four districts of interest in the northern sector were selected, a sub-cluster was taken from a list of all communities belonging to the district and three were randomly selected. In each sub-cluster, a random selection of farmers was made in each of the sampled the communities. This system allowed yielded 199 crop budgets and datasets on maize producing households The collection of secondary data on tariffs, fees, charges and other prices needed to compute the social costs were collected from ministries and research centres.

The Policy Analysis Matrix is used to measure the contribution of a specific agriculture system to the private income to farmers and to the general performance of the economy. This approach allows to compare and identify policies that contribute to increase farmers private income and national income (Monke & Pearson 1989; Winter-Nelson & Aggrey-Fynn 2008)**.** The advantage of this approach is that it quantifies the economic efficiency of a given production system and the effects of the policy impacts on production technologies. The PAM uses budgets from farms, in this case to estimate separately the effects of micro- and macro policies, the market failures and distortions on the diverse steps in the production chain. Therefore, the outcome of the matrix allows to assess policies that support the development of new technologies (Shapiro & Staal 1995).

Table 1: The Policy Analysis Matrix (PAM)

	Revenues	Cost		Profits
		Tradable Inputs	Non-Tradable Inputs	
Private Prices	A	B	C	D
Social prices	E	F	G	H
Divergence	I	J	K	L

Source: Adapted from Monke and Person 1989

D = A-B-C	Private profits
H = E-F-G	Social Profits
I = A-E	Output Transfers
J = B-F	Input Transfers
K = C-G	Factor Transfers
L = D-H=I-J-K	Net Transfers

The top row represents the revenues and costs of private prices evaluated at market prices. Those reflect the revenue and the cost that farmers face in the existing market, divided in two categories, tradable inputs (e.g. fertilizer and fuel)and domestic factors of production, generally considered as non-tradable nature (e.g. land, labour and capital).

Values of the second row are computed by adjusting the individual components of the first row, using economic prices. As proxy for the economic prices, world market prices adjusted to their import and export parity price are used. Opportunity costs are used to estimate the domestic factors of production.

The third and last row is calculated by subtracting the values of the social costs from the private costs. It shows the effect of distorting policies and market failures on economic efficiency. It is the value of the output transferred from society to individuals (A-E). The same method can be applied for transfer of the tradable inputs and the domestic factor. Economic efficiency can be measured by social profitability, which is calculated by subtracting the sum of the cost of tradable and non-tradable inputs (F+G) from social revenues (E). Social values are calculated, in the case of exported goods in F.O.B. (free on board) prices and import goods in C.I.F. (cost, insurance, freight) prices. This is necessary in order to validate that the social prices are out of policy interventions and in the assumption of competitive markets for inputs and outputs (Huang et al. n.d.). The private profitability indicates the competiveness of the given commodity at the current technology, input cost, output prices and policy transfers. If the value is higher than 0 it implies comparative advantage.

3.2 Additional indicators for policy analysis

The PAM additionally allows computing associated ratio indicators. The Nominal Protection Coefficient for Outputs (NPC_0) and tradable Inputs (NPC_1)are ratios of the private value to the social value, respectively for the revenue and the tradable inputs. The NPC is used to determine how well government policies give incentives to grow specific crops. If the NPC (A/E) of a crop is greater than 1, the domestic price is higher than the price on the international market; farmers in the country have an incentive to produce it.

The Effective Protection Coefficient (EPC) is measured as a ratio between the value added in the domestic market and the value added in the international market prices (A-B)/(E-F). If the value is greater than 1, that indicates positive commodity policies (e.g. subsidy to farmer); if the EPC value is less than 1 it means that negative incentives to farmers (e.g. taxes) are applied.

Cost Benefit Ratio (CBR) this is a broader measure of economic efficiency and indicates private profitability. CBR <1 implies private profit (Monke & Pearson 1989).

The Domestic Resource Cost (DRC) measures the comparative advantage or the economic profitability of crop production. The case of social costs for land cannot be assessed because of lacking information on alternatives, as the DRC can be calculated with respect to labour and capital only. The DRC is the ratio of the value of non-tradable inputs to the value added in economic terms G/(E-F), furthermore it is used as a proxy to measure social profits. It indicates the cost of the non-tradable inputs that has to be rose get one more unit of value added in economic terms. The lower the values (lower than 1) as greater the comparative advantage the country has in the production of the commodity (Monke & Pearson 1989).

3.3 Cobb-Douglas production function

The C-D function can also be employed to calculate the amount of input that is required the next production season and analyse the required investment, to maximize returns. The C-D function is especially used in production analysis since it gives direct elasticity's and allows to calculating returns to scales (Bravo-Ureta & Evenson 1994).

The Cobb-Douglas production function in it general form is given below:

$$Q = AL^{\alpha}K^{\beta}$$

Where, Q stands for the total production, it can be measured in physical units or as the monetary value of the goods, L = labour input generally measured in mandays, K = capital input, is the most problematic variable since only capital that is actually utilized should be treated as input, which is not easy to determine since it is a aggregation of different components. A stands for the total factor productivity, which includes inputs that would be omitted otherwise but have a influence on the overall productivity (weather, knowledge of workers, technology etc..). α and β are the output elasticity of labour and capital, respectively(Brooks et al. 2007).

In addition if: $\alpha + \beta = 1$, the C-D function shows constant returns to scale, if $\alpha + \beta < 1$, returns to scale are decreasing, and if $\alpha + \beta > 1$ returns to scale are increasing.

The C-D function is linear in logarithmic transformation and can expressed as:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \, \mathrm{In} X_3 + \ldots\ldots\ldots \beta_n \mathrm{In} X_n$$

4 Results

4.1 The crop budget

The crop budget is the first important result of the analysis, production revenues and cost of inputs, thus the determination of the farm profits. Table 2 represents the outcome of the crop budget, the allocation of household resources and the output of the communities.

Maize production is on average profitable at a private level in the surveyed districts even if the net revenues are more than five times lower l for the farmers producing less than 1.5Mt/ha, if wages of household members are not budgeted revenues of high output is only twice as much since resource allocation is more directed towards tradable inputs.

Table 2: Crop budget of different systems in the four districts (values in GHS/ha unless otherwise specified)

		High Output System	Low Output system
Number of Households		54	115
Tradable Inputs		152	86
Non Tradable Factors	**Household labour**	141.5	106
	Wage Labour	68	30
Own capita and Tools and Small Implements		23	5
Service and Non-tradable Intermediate Inputs		116	70
Total Costs		524	324.5
Total Grain (Kg/Ha)		2149	938
Total Revenue		855	389
Net Revenue		367	64
Net Revenue Without Households Labour		**508**	**217**

Source: Own survey data

The crop budget serves as basis for the calculation of the following PAM and the C-D calculations.

4.2 Results of the policy analysis matrix

Table 3 and 4 present the results of a PAM for two output systems. Private profits are the outcomes of the crop budget and reflect the difference in revenues and costs at current market prices. Whereas social prices (second row, letter H) in the tables are used to measures the efficiency and competitive advantage of maize production. The negative outcomes in the lowest production systems indicate inefficient use of economic resources, suggesting that import costs are lower than production costs using existing policies and technology.

Table 3: Average of PAM values in GHS/ha of 121 farmers in the low output systems

Low	Revenues	Input Costs	Factor Cost	Profits
Private	670 (A)	154 (B)	345 (C)	171 (D)
Social	567 (E)	154 (F)	356 (G)	57 (H)
Divergentes	103 (I)	-0.1 (J)	-13 (K)	120 (L)

Source: Own survey data

Table 4: Average of PAM values in GHS/ha of 54 farmers in the high output systems

High	Revenues	Input Costs	Factor Cost	Profits
Private	890 (A)	186 (B)	334 (C)	369 (D)
Social	746 (E)	191 (F)	339 (G)	234 (H)
Divergences	145 (I)	-4 (J)	-6 (K)	155 (L)

Source: Own survey data

Private and social prices are the import price plus inland transport costs, adjusted for processing losses. The private prices are validated at market prices. In the second row, outputs (E) are valued at C.I.F. prices since they are treated as exportable, inputs (F) are valued according to F.O.B. prices since they are imported goods, and international prices are used since the products are traded at world prices.

The divergence, in the third row, between the observed private (actual market) price and the estimated social (efficiency) price are explained by market failures or policies (Ogbe et al. 2011). Two possible policies influence the divergence observed in input transfers (J) and output transfers (I) between reported and international market prices: either commodity-specific policies or exchange rate policy. The slight overvaluation of the currency indicates a small detergency in the input transfers (J), even though very low. All tradable inputs are calculated by separating each component of the intermediate inputs into factor costs and tradable input categories. On the other hand, output transfers (I) are relatively high compared to input transfers (J). This factor (I) indicates the market price minus the efficiency valuation of maize; the divergence can be attributed to distorting policies, in particular to import and sales tax on goods, since market failures are difficult to identify empirically.

Factor transfers K are the difference between all factors of production (C) and their social cost (G): the effects of distorting policies affecting output or factor markets are considered to be very common in developing countries.

Net transfers (L) are an important result of the PAM and show the extent of the inefficiency of the system; policy can be aimed to reduce the degree of distortion. The positive net transfers (L) suggest that the net effect of policy intervention is increasing production at household level in all systems.

4.3 protection and competitiveness coefficients

The protection and competitiveness coefficients of the output systems in the four districts are summarized in table 5.

Table 5: Protection and competitiveness coefficients derived from PAM

	NPCo	NPCi	EPC	CBR	DRC
High	1.19	0.98	1.27	0.58	0.61
Low	1.18	1	1.25	0.74	0.86

Source: Own survey data

The NPC_O coefficients greater than one, indicating policy protecting the output price at domestic level, that rise farm gate prices to a higher level than the world reference maize price. The NPC_I values are close to one indicates that the input cost in these systems is only slightly lower and equal to the international price.

The effective protection rate (EPC = (A-B)/ (E-F)) indicates the effect of product policies on the agricultural system, combining the effect of commodity price policy. In this case for example, governments encourage the adoption of a new technology subsidize inputs and at the same time reduce the prices of outputs. Therefore, producers are protected by policy intervention on value added processes. This result is confirmed by the values of the NPC_O and NPC_I. Both inputs and outputs are protected by commodity (price) policies.

The indicators of private profitability are the cost benefit ratio (CBR), the private cost ratio and private profits. The values of the CBR in the low and high production systems suggest that 0.74 and 0.58GHS are needed respectively to generate 1 GHS of output.

The indicators of comparative advantage are domestic resource cost (DRC) and social profits (H). For both output systems the DRC is less than one, indicating that the systems are economically efficient, which is confirmed by SCB values that show efficiency in the use of fixed factors. However, DRC indicates the cost of domestic factors incurred to obtain one unit of added value in economic terms. The value of 0.61 in in the high output system indicates a higher comparative advantage of those farmers in the production of maize.

4.4 Cobb-Douglas function

The variables included in the regression model were resources available to farmers, from which we were interested to determine the impact on output of maize in kg/ha.

Table 6 shows the variables used and their significance in describing the amount of output in the lowest production system. It also shows the accuracy of the variables describing the amount of output in the low output system. In both production functions, *Y* the dependent variable is the amount of maize in kilograms per hectare; *X* are the dependent variables.

The positive relationship between fertilizer input and output was expected. The impact is tough is disappointing, 10kg of additional fertilizer increase maize yield by 0.5%. Application of agrochemicals as pesticides, had a stronger effect on yield, 10 units increase maize output by 2.2%. The increase of output price had the strongest effect; the increase of 10GHC per kilogramme of maize has the potential to increase production by 40%. The positive sign relationship between output price and maize output also meets our expectation. Although a significant and a positive relationship were expected between family labour and output, this did not emerge in the results.

Table 6: Inputs used in the calculation of the production function for low output farmers.

Variables	Coefficients		
	B	Std. Error	Sig.
Amount of Fertilizer (kg/ha)	0.05	0.03	0.09**
Amount of Chemicals (kg/ha)	0.2	0.06	0.001***
Use of improved Seeds	-0.1	0.15	0.3
Family labour(mandays/ha)	-0.008	0.04	0.8
Extension service	0.04	0.12	0.7
Rainfall (mm/year)	0.04	0.6	0.9
Price of output (GHS/kg)	0.4	0.15	0.01**
Wage labour (mandays/ha)	-0.009	0.03	0.8
Soil	0.28	0.17	0.1

Dependent Variable: Maize output (kg/ha)
N=115 R=0.480 R^2=0.230 F=3.485 Sig=0.001***

Source: Own survey data
Note: Significant at 5% level ** at 1% level ***

Table 7: Inputs used in the calculation of the production function for high output farmers.

Variables	Coefficients		
	B	Std. Error	Sig.
Amount of Fertilizer (kg/ha)	0.03	0.02	0.2
Amount of Chemicals (kg/ha)	0.009	0.04	0.8
Use of improved Seeds	0.2	0.1	0.027**
Family labour(mandays/ha)	0.1	0.04	0.008**
Extension service	-0.06	0.09	0.5
Rainfall (mm/year)	-0.08	0.4	0.8
Price of output (GHS/kg)	0.3	0.1	0.023**
Wage labour (mandays/ha)	0.05	0.02	0.044**
Soil	0.33	0.1	0.006**

Dependent Variable: Maize output (kg/ha)
N=54 R=0.617 R^2=0.381 F=3.008 Sig=0.007***

Source: Own survey data
Note: Significant at 5% level ** at 1% level ***

Table 7 reports the key statistics of inputs used by farmers of the high output system. The positive signs of improved seed, family labour, hired labour and price of output all meets our expectations. Better effects are achieved even as not as pronounced as in the low output system, by a higher price of the harvested maize, 10GHC price increase would lead to an increase production of 3% . Interestingly, fertilizers and agrochemicals, did not show any effect on maize yield.

5 Discussion

The current set of agricultural and macroeconomic policies are consistent with competitiveness of maize production as import substitution in the high scale systems (producing more than 1.5 Mt/ha) in the northern sector of Ghana. This study assessed the comparative advantage from the side of the producer of importing substitutes, against C.I.F. prices, the complementary view would assess the comparative advantage against F.O.B. prices. The data suggest that, Ghana might not be able to export but is still better off with the domestic production than importing, since C.I.F prices are high compared to F.O.B. prices, respectively 407 and 66 $/Mt.

5.1 Assessing the Comparative Advantage of Maize Production

The most valuable crops grown in Ghana for the international market are cocoa, fruit and horticulture products. Cocoa alone contributed to 32% of the total foreign exchange earned in 2009. Even though Ghana is exporting a substantial amount of food products, agricultural imports are rising at the same time. The import bills of imported maize rose from 10 million US dollars in 2004 to 21million in 2008, with a peak of 25 million US dollars in 2006, according to FAO (FAOSTAT).

The output of the PAM shows that positive private profits are achieved by farmers, indicating the cost effectiveness of the systems in the short to medium term. Farmers, who achieve higher output, use scarce resources more efficiently and do not have to rely on government intervention. The lowest production systems consequently depend on government intervention at the margin and do not have a comparative advantage in maize production. The divergence between private and social costs of domestic factors (K) are negative, indicate a reduction of cost to the private agent, showing that there are interventions that lower the cost of capital and labour. Nevertheless, policy reforms should be aimed at higher support for the rural capital market (Nair & Fissha 2010). The positive values between private and social profits (L) suggest that the net effect of policies on maize production increases profitability in all the systems analysed.

The ratios of the protection and competitiveness coefficients are summarized in table 5.The value of the nominal protection coefficient on tradable outputs, NPCo, is higher than one in all systems, indicating that the production of maize is protected by policies such as subsidies. Furthermore, the inland farm-gate price is higher than the world trade price indicating import duty on maize, at the relatively high level of 20%, to protect domestic production.

The NPC_I of less than one indicates that the price of tradable inputs is lower than the international market price, suggesting that policies in Ghana are reducing the cost of tradable inputs and a positive policy transfer to the agricultural system, which is confirmed by the government fertilizer subsidy program. These two effects, output price policy and tradable input price, are combined in the effective protection coefficient (EPC). The EPC greater than one indicates how much the observed value differs from what it would be without policy effects, in this case the value added in private prices and value added in world prices. The policy transfers from product market-output and tradable-input policies are about 25% greater than private profits would be without policy interventions. An additional indicator of incentives is the subsidy ratio to producer (SRP), which indicates the “proportion of revenues in world prices that would be required if a single subsidy or tax were substituted for the entire set of commodity and macroeconomic policies”(Monke & Pearson 1989 p.18). The domestic resource cost, DRC, is an indicator of efficiency closely related to the social profits row (E, F, G and H). In the low output systems, the value is closer to one, indicating that the value of domestic resources used in production higher. This suggests that at the current level of technology and input management, the systems are not using scarce resources efficiently. Current policies in Ghana are therefore not providing private incentives that generate social profits, and should also aim to achieve a comparative advantage of these systems as well, since they constitute a large share of the farms in the northern area of Ghana. The lowest output systems waste scare resources, producing social costs which are higher than international prices; it would therefore be “cheaper” to import.

The PAM result shows that domestic maize production is socially profitable in the high production systems , implying that Ghana has a comparative advantage in maize production were if the system produce more than 1.5Mt/ha. Systems producing below average (1.5Mt/ha), in the northern part of the country were conditions are sub-optimal and more inputs are needed the farms have no comparative advantage in maize production.

With introduction of the new policy, small land-holders had access to initially economically prohibitive inputs. Low output farmers using fertilizers now depend on government intervention. Factor transfers indicate small support of policy intervention in the capital market, which is not very well developed (Nair & Fissha 2010), but a lower cost of capital would increase private and social profits.

The amount of public funds allocated for the fertilizer subsidy program since its inception has more than tripled, from US$10 million[1] in 2008 to $35 million in 2011 (Benin et al. 2011), to more than $60 million in 2012 (Ghana, MoFA 2012).

The potential of this technology is not yet fully realised. The strategy should not only aim to increase the amount of fertilizer used but also direct a synergy of inputs and management skills to achieve higher outputs. The timing of fertilizer applications is of primary importance to exploit the full input potential. It is also known that improved maize varieties respond as well to increased use of fertilizer as the local varieties, which are naturally adapted to harsh conditions. Based on this assumption, use of high yielding varieties could maximize the effect of greater fertilizer application. Traditionally, farmers save seeds from a previous harvest for the next growing season. This reduces input costs and problems with an insufficient seed supply. Only 22% of the land cultivated with maize of the farm owners interviewed was sown with purchased seeds. Only 7/ out of 52 farmers recalled that the extension service officer provided information on improved seeds. The main constraint against adoption of improved seeds mentioned by farmers was lack of financial means (74%), the perception that the quality of recycled seeds was sufficient (26%) and lack of knowledge about improved seeds (10%). The MoFA district office was reported to be one of the few places where the seeds could be purchased; the input dealers interviewed did not have seeds to sell. Poor availability is also a reason of low production rate (Feder et al. 1985). Open pollinated varieties (OPVs) are preferred by the households because the seeds can be save for the next season.

The most common varieties include Okomasa, Obatampaa, Dobid, Laposta and Dotzi. The latter is described as early maturing and drought resistant. Mamaba, a hybrid maize used in Ghana, was not mentioned by the households even though it yields up to 7Mt/ha, matures early and is drought resistant (Wiredu et al. 2008). Beside the price (50% more expensive than Obatanpa), the main constraint is that the F1 population loses the characteristics of the parent when resown. Studies reveal that farmers investing in improved seeds may increase their yield to 2.3 Mt/ha and those using seeds in combination with fertilizers can increase it to 3.4 Mt/ha (WABS 2008). The study by the Savanna Agriculture Institute (SARI) reported an increase of about 50% in dry areas. Thus the first scenario assumed a yield increase of 50% due to use of improved seed varieties. All other parameters were unchanged. The increase in output favoured maize farmers in all systems and regions (Tahirou et al. 2009). Private profits and competitiveness increased to positive levels in all systems with PCR less than one. These results are in line with the study in Nigeria by Ogbe et al. 2011 where the increased yield increased private and social profits.

The production function estimates indicated that additional tradable off-farm input (fertilizer and agrochemicals) has a greater impact on productivity than an increase in family and wage labour in the low output system, since high output farmers apply proportionally more fertilizer and agri-inputs. *Vice versa*, lowest input farmers use proportionally more family and wage labour in their farming system. The result suggests that the relatively more abundant factor explains the more significant quantity of output (Yilma & Berg n.d.).

The use of improved seeds was a significant variable for yield among high output farmers and from the survey data, it is observed that more than twice as much (68%) of the amount of improved seeds is effectively used in high output systems.

The extension service did not have a significant effect on farm productivity. Past analyses have confirmed this outcome for farming systems in developing countries, for example in Indonesia (Feder et al. 2003). Extension service and the education system are key policy instruments to improve productivity in agriculture (Binam et al. 2008). Variations in rainfall were expected to affect productivity, but as shown in the model, was not significant. The fact that low and high output plots were located in all districts could explain the minor influence of different rainfall patterns. The same is true of the soil fertility variable. The production function reveals that the price of maize affects the amount produced in both systems. It can be assumed that farmers also calibrate their effort and use of inputs among cultivated crops in relation to output price. As learned from research which employed field trials the potential for higher yields is given, but results from the production function show that fertilizer do not play a major role for poorly producing systems and none for farmers which achieve better results. The Ghanaian government started in 2008 to run a fertilizer subsidy programme to increase the access to fertilizer to small scale farmers in the assumption that an enhanced affordability would increase application quantity and application rates of the fertilizer, which in the finally should lead to increased crop yield. At first this measure was carried out as a voucher program, in the study year it was implemented as a waybill system by subsidising the product directly at the entry port, this kind of system makes the fertilizer available to all farmers that can afford the subsidized price (Chapoto et al. 2013). The fertilizer subsidy programme targets one factors contributing to increase yields and results show a set of factors which could be addressed in combination to increase domestic maize production.

5.2 Factors Influencing Production in Northern Ghana

Major constraints perceived by the farmers interviewed include other aspects, such access to financial services to cover production costs, access to extension services and pest and disease control, which are high priorities. Emphasis on plant configuration by extension service providers is not justified by farmer needs. The lack of information on improved seeds, insecticides and pesticides, as well as lack of a well-developed seed supply system clearly affect the adoption rate of such technologies (Doss & Morris 2001).

The production function estimates indicated that additional tradable off-farm input (fertilizer and agrochemicals) has a greater impact on productivity than an increase in family and wage labour in the low output system, since high output farmers apply proportionally more fertilizer and agri-inputs. Vice versa, lowest input farmers use proportionally more family and wage labour in their farming system. The result suggests that the relatively more abundant factor explains the more significant quantity of output (Yilma & Berg n.d.).

The use of improved seeds was a significant variable for yield among high output farmers and from the survey data, it is observed that more than twice as much (68%) of the amount of improved seeds is effectively used in high output systems.

The extension service did not have a significant effect on farm productivity. Past analyses have confirmed this outcome for farming systems in developing countries, for example in Indonesia (Feder et al. 2003). Extension service and the education system are key policy instruments to improve productivity in agriculture (Binam et al. 2008). Variations in rainfall were expected to affect productivity, but as shown in the model, was not significant. The fact that low and high output plots were located in all districts could explain the minor influence of different rainfall patterns. The same is true of the soil fertility variable. The production function reveals that the price of maize affects the amount produced in both systems. It can be assumed that farmers also calibrate their effort and use of inputs among cultivated crops in relation to output price. As learned from research which employed field trials the potential for higher yields is given, but results from the production function show that fertilizer do not play a major role for poorly producing systems and none for farmers which achieve better results. The Ghanaian government started in 2008 to run a fertilizer subsidy programme to increase the access to fertilizer to small scale farmers in the assumption that an enhanced affordability would increase application quantity and application rates of the fertilizer, which in the finally should lead to increased crop yield. At first this measure was carried out as a voucher program, in the study year it was implemented as a waybill system by subsidising the product directly at the entry port, this kind of system makes the fertilizer available to all farmers that can afford the subsidized price (Banful 2011, (Chapoto et al. 2013). The fertilizer subsidy programme targets one factors contributing to increase yields and results show a set of factors which could be addressed in combination to increase domestic maize production. A vast number studies showed improved seeds can increase small scale agriculture productivity. From the interviews we assessed that Ghanaian farmers would be positive to improved seeds, if they had better access. Though some farmers claimed that they do not need seeds or that they are not profitable, the price was an important factor for them. It can be assumed that profitability is the major issue. The price of seeds could be lower if there was a well-functioning information and distribution system of improved seeds in the northern compartment of Ghana. However, a price reduction does not always imply higher profitability (Morris et al. 2000). Poor adaptation of small scale farmers is related to the high fixed cost implied by adoption and use of this input, as access to improved seeds is inadequate. The use of improved seeds differs from other technologies because it is relatively inexpensive and simple, since changes to current practices are few (Tahirou et al. 2009). Improvement in infrastructure to facilitate access in distant and remote areas and information on yield implications are priorities for strengthening demand. The absence of a physical market also affects the flow of information and goods (Diao et al. 2008).

The effort to increment the use of fertilizers was successful compared to the results obtained in 2008. Unfortunately the subsidy program did not include complementary the promotion of modern seed varieties. The World Bank underlines the need to offer major inputs (fertilizers, agrochemicals and improved seed) as a package and to improve the current fragmented distribution network (World Bank 2009). To achieve full productive potential, inputs must complement each other through good management and farming skills. These include correct timing and specific fertilizer types for certain soils, as observed by Diagna and Zeller at al. 2001 in Malawi. We observe that farmers mostly mentioned only two types of fertilizer with the same composition, SoA and NPK (15-15-15), since they were the most available. The correct timing of mineral fertilizer application is important to ensure maximum efficiency and reduce runoff and leaching. Cost-efficient measures to improve soil fertility can also be achieved through soil conserving practices, such as leaving crop residues in the field to increase soil organic matter and reduce the kinetic energy of runoff, and using manure. Fertilizer use must also be supported by training to avoid wastage and negative externalities (FAO 2011).

An empirical study in 2011 examined the effect of the political characteristics of districts on fertilizer voucher allocation in 2008. The program first targeted districts where the ruling party had lost support in the previous elections and districts that registered high percentage losses. This type of allocation was not efficiency-based but politically orientated, resulting in fewer vouchers to poorer farmers. According to this study, the three regions where we conducted our survey rank in the four top positions for average number of vouchers available per 1000 farmers (Banful 2011) .

Farm management has to be supported instead of considering only one factor. The low effect of fertilizers could also be explained by improper timing or methods of application, for verification of these assumption further studies in the region are required. The northern sector of the country is and its economy is informally divided from the south. To some extent geographic and climatic differences play a role in this differentiation. The south has most natural resources, such as minerals, and access to the Gulf of Guinea and Lake Volta. The southern compartment exploits a better educated labour force and more developed infrastructure. The political origin of this division, with development projects concentrated in the south, is narrowing today due to higher capital investments in the north. The programs undertaken concentrate on upgrading of roads running north-south, extending the national electricity grid and increasing investment in education (Wolter 2008).

The condition of local roads influences rural development, since infrastructure reduces the cost of investments in extension services, financial services, provision of agricultural inputs, and output to markets. A well-developed rural road system can reduce price volatility and the gap between food–surplus and food-deficit areas. Reducing transport costs and improving the road network is the measure with the highest social returns to the country (Diao et al. 2008).

5.3 Policy Implications

Since maize is a much appreciated cereal in Ghana, there is significant margin for fully capturing the increasing domestic market. We argue that technical improvement, new technologies, access to financial means and efficient infrastructure are ways to increase productivity and the reduce costs faced by smallholder farmers.

The policy recommendations made, based on these findings are: The need to improve the quality of the extension services to target the real constraints farmers face (e.g. implementing the participatory approach). The use of fertilizer should be coupled with other inputs to maximize the efficiency of each measure. Additionally, stable input markets would help to attract the private sector which is expected to increase the competition between wholesalers and wholesalers and importers, and improve the distribution network. The lack of access to credit should be addressed to decrease the risk aversion of farmers, in this case the recommendation made is to establish rural microfinance institutions and promote financial self-help groups or solidarity groups. The improvement of the infrastructure network is another urgent measure for communities in rural areas, to reduce the distance between markets, increase the access to them and reduce transport costs.

Any effort to enhance private and social incomes through higher yield, access to credit and market, improved infrastructure needs further analysis to ensure that revenue and savings are passed on to producers as higher profits.

6 Conclusions

In this research we attempted to analyse the comparative advantage of two systems of maize production in the northern sector of Ghana, using the Policy Analysis Matrix approach.

The agricultural sector is of central importance in Ghana's economy, and as stated by many authors, agricultural growth in early stages of development has the greatest impact on overall economic performance and poverty reduction.

The data show that even the northern regions of Ghana, where the environmental conditions are harsh for crop production, more efficient systems have a comparative advantage in maize production compared to the imported commodity price. The constraints preventing small-scale farmers from realising the full potential of their farming system are a combination of lack of access to information and research findings on the physical and technological aspects of crop production, and to modern technologies. This is coupled with a weak financial and credit system and a poor infrastructure network. This data was confirmed by the Cobb-Douglas production function which showed that the use of fertilizer was not a determinant factor to explain the output. This is an important finding especially, looking at the controversial policy issue, debated in many Africa countries.

In the recent past, the increase in agricultural productivity in Ghana was mainly based on expansion of cropping area. The country therefore has a high potential to exploit the advantages of the green revolution, but requires large investments and strong policy implementation. The fertilizer subsidy programme is an expensive programme for the Ghanaian government which served its purpose only in production systems that are already better off and did contribute to yield increase in low output systems. Strategies to exploit synergies between different policy instruments and to consider different aspects of the agricultural production are needed to boost yields. The challenge that Ghana face is to invest in efficient, productivity-driven, economically and environmentally sustainable agriculture.

In conclusion, we it consider essential to combine knowledge and access to new technologies to improve soft and hard infrastructure and reach larger numbers of rural communities. Single factors need to be combined and used in synergy to realise the full efficiency of each.

References

Banful, A.B., 2011. Old Problems in the New Solutions? Politically Motivated Allocation of Program Benefits and the “New”Fertilizer Subsidies. *World Development*, 39, pp.1166-1176.

Binam, N.J. et al., 2008. Factors affecting the technical efficiency among smallholder farmers in the slash and burn agriculture zone of Cameroon. *Food Policy*, 29(2004), pp.531-545.

Bravo-Ureta, B.E. & Evenson, R.E., 1994. Efficiency in agricultural production : the case of peasant farmers in eastern Paraguay. *Agricultural Economics*, 10, pp.27-37.

Brooks, J., Croppenstedt, A. & Aggrey-fynn, E., 2007. Distortions to Agricultural Incentives in Ghana. *World*.

Chapoto, A., & Ragasa, C. 2013. Moving in the Right Direction? Maize Productivity and Fertilizer Use and Use Intensity in Ghana. *IFPRI Discussion Paper 0131. Ghana.*

Cudjoe, G., Breisinger, C. & Diao, X., 2010. Local impacts of a global crisis: Food price transmission, consumer welfare and poverty in Ghana. *Food Policy*, 35(4), pp.294-302. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0306919210000266 [Accessed September 23, 2011].

Diao, X., Headey, D. & Johnson, M., 2008. Toward a green revolution in Africa: what would it achieve, and what would it require? Agricultural Economics, 39, pp.539-550. Available at: http://doi.wiley.com/10.1111/j.1574-0862.2008.00358.x [Accessed September 30, 2011]

Doss, C.R. & Morris, M.L., 2001. How does gender affect the adoption of agricultural innovations ? The case of improved maize technology in Ghana. Agricultural Economics, 25, pp.27-39.

FAO, 2005. Fertilizer use by crop in Ghana. *FAO*.

FAO, 2011. *FAO ’ s Initiative on Soaring Food Prices Guide for Policy and Programmatic Actions at Country Level to Address High Food Prices*,

Feder, G., Just, R.E. & Zilberman, D., 1985. Adoption of Agricultural Innovations in Developing Countries : A Survey. *Economic Development and Cultural Change*, 33(2), pp.255-298.

Feder, G., Murgai, R. & Quizon, J.B., 2003. Sending Farmers Back to School: The Impact of Farmers Field Schools in Indonesia. *World Bank*, (April).

ISSER, 2010. *The State of the Ghanian Economy 2009*, Accra.

MoFA, 2010a. *AGRICULTURE IN GHANA . Facts and Figures 2010*,

Monke, E. & Pearson, S., 1989. *The policy analysis matrix for agricultural development*, Available at: http://www.tandfonline.com/doi/abs/10.1080/03768359008439507.

Morris, M.L., Tripp, R. & Dankyi, A.A., 2000. Adoption and Impacts A Case Study of the of Improved Ghana Grains Maize Production Development Project Technology : Adoption and Impacts of Improved Maize Production Technology : A Case Study of the Ghana Grains. *Development*.

Nair, A. & Fissha, A., 2010. *Rural Banking: The Case of Rural and Community Banks in Ghana*,

Ogbe, O.A., Olusegun Okoruwa, V. & Olaide Jelili, S., 2011. COMPETITIVNESS OF NIGERIAN RICE AND MAIZE PRODUCTION ECOLOGIES: A POLICY ANALYSIS APPROACH. *Tropical and Subtropical Agroecosystems*, 14, pp.493- 500.

Regasa,C., Dankyi, A., Acheampong, P., Wiredu, A.N., Chapoto, A., Asamoah, M. & Tripp, R. 2013. Patterns of adoption of improved maize technologies in Ghana. GSSP WORKING PAPER, IFPRI, Ghana.

Seini, A.W., 2002. *AGRICULTURAL GROWTH AND COMPETITIVENESS UNDER POLICY REFORMS IN GHANA AGRICULTURAL GROWTH AND COMPETITIVENESS UNDER*, ISSER The Institute of Statistical, Social and Economic Research, University of Ghana, Legon.

Tahirou, A. et al., 2009. *Assessing the constraints affecting production and deployment of maize seed in DTMA countries of West Africa production and deployment of maize seed in DTMA countries of West Africa*,

WABS, 2008. *Maize Value Chain Study in Ghana : Enhancing Efficiency and Competitiveness*,

Winter-Nelson, A. & Aggrey-Fynn, E., 2008. Identifying Opportunities in Ghana ' s Agriculture : Results from a Policy Analysis Matrix. *Communications*.

Wolter, D., 2008. Ghana: Agriculture is Becoming a Business. *Development*, oecd.

World Bank, 2009. *Awakening Africa's Sleeping giant: Prospects for Commercial Agriculture in the Guinea Savannah Zone and Beyond*,

World Bank, 2015 http://www.worldbank.org/en/country/ghana.

Yilma, T. & Berg, E., Technical Efficiency of Maize Production in Southwestern Ethiopia: a case of Jimma zone.