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TOWARDS A SUSTAINABLE SOIL FERTILITY STRATEGY IN GHANA

Report submitted to the
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Food Security Policy *Research Papers*

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EXECUTIVE SUMMARY

Most efforts to raise fertilizer use in SSA over the past decade have focused on fertilizer subsidies and targeted credit programmes with hopes that these programmes could later be withdrawn once the profitability of fertilizer use has been made clear to adopting farmers and once they have become sufficiently capitalized to be able to afford fertilizer on their own. This line of reasoning under-emphasizes the evidence that many smallholder farmers obtain very low crop response rates to inorganic fertilizer application and hence cannot use it profitably at full market prices. A central hypothesis of this study is that Ghanaian farmers will demand increasing quantities of fertilizer when they can utilize it more profitably, and that doing so will require improved agronomic and soil management practices that enable farmers to achieve higher crop response rates to fertilizer application.

The study's findings are based on reviews of existing studies from Ghana and the wider region, key informant interviews of cocoa and maize farmers, international and local scientists, fertilizer distribution companies and government officials. The study also benefited from feedback obtained on the team's preliminary findings, which were presented at the conference convened by GSSP/IFPRI, APSP, WAFP and AFAP on "Towards a Sustainable Soil Fertility Strategy in Ghana," 2 February, 2015 in Accra which brought together roughly 60 international and local researchers and agricultural sector stakeholders from the public and private sectors.

The study finds that low crop response to inorganic fertilizer is one of several major problems impeding the profitable use of fertilizer. There is strong evidence in the literature that if fertilizer use does not increase the value of crop output more so than the costs of using it, farmers are unlikely to use it except in cases where the product is heavily subsidized. There is also robust evidence that farmers respond to incentives. Farmers will demand more fertilizer if obtaining higher crop response to fertilizer enable them to utilize it more profitably. Doing so is likely to require greater public investment in effective systems of agricultural research and extension that emphasize bi-directional learning between farmers of varying resource constraints and agro-ecologies, extension workers, and researchers. Other impediments to the profitable use of fertilizer on food crops in Ghana are related to the uncertainties and late announcements of the Fertilizer Subsidy Programme, the fixed transport margins imposed on fertilizer distributors, which constrains farmers' access to fertilizers in remote rural areas, and the widespread practice of seasonal burning of grassland, which contributes to problems of soil infertility.

There is lack of specific information on the profitability of the different soil-crop-fertilizer combinations that could be employed in Ghana's diverse agro-ecologies and soil types. The lack of such information on crop-fertilizer profitability across the country, and the various farmer management factors influencing response rates, means that researchers and extension agents are not in an informed position to provide more than generalized guidance to farmers about 'best practices'. Sub-optimal farmer practices with regard to soil fertility management increases yield risk, impedes farmers' incentives to use fertilizer, and results in foregone agricultural output likely to exceed USD400 million annually. Knowledge of soil characteristics and processes regulating nutrient availability and supply to crops is essential to raise productivity per unit of fertilizer nutrient applied. The recommendation of the African Fertilizer Summit (2006) to increase fertilizer use from 8 to 50 Kg/ha nutrients by 2015 reinforces the importance of both inorganic and organic fertilizer for increasing crop productivity and attaining food security and rural wellbeing in Ghana. The impact of this target will however vary depending upon the agronomic efficiency of applied fertilizer. This efficiency varies across ecological zones, farms and fields within farms and greatly affects the returns to the recommended 50 Kg/ha. Insufficient and unbalanced fertilization of soils using fertilizers as well as lack of nutrient conservation technology adoption by farmers contribute to accelerating the rapid decline in soil fertility. The efficient uses of both inorganic and organic fertilizers, through Integrated Nutrient Management approach, will form an important element of a holistic approach for sustainably increasing crop production in Ghana.

ACRONYMS

AFAP	African Fertilizer and Agribusiness Partnership
AgDPO	Agricultural Development Policy Operation
APSP	Agricultural Policy Support Project
ASRP	Agricultural Services Rehabilitation Project
ASWG	Agricultural Sector Working Group
CAD	Canadian dollar
COCOBOD	Ghana Cocoa Board
DADU	District Agricultural Development Unit
DAEA	District Agricultural Extension Agent
DAP	diammonium phosphate
ERP	Economy Recovery Program
FABS	Food and Agriculture Budget Support
FASDEP II	Food and Agricultural Sector Development Policy II
GAIDA	Ghana Agri-Input Dealers Association
GFAP	Ghana Federation of Agriculture Producers
GFSP	Ghana's Fertilizer Subsidy Programme
GHC	Ghanaian cedi
GoG	Government of Ghana
GSGDA	Ghana's Shared Growth and Development Agenda
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Center
KM	Kaleidoscope Model
MDAs	ministries, departments, and agencies
MDBS	Multi-Donor Budget Support
METASIP	Medium Term Agriculture Sector Investment Plan
MoFA	Ministry of Food and Agriculture
MoFEP	Ministry of Finance and Planning
MP	Member of Parliament
NDC	National Democratic Congress
NPK	nitrogen–phosphorous–potassium
NPP	New Patriotic Party
PFAG	Peasant Farmers Association of Ghana
PPMED	Policy, Planning, Monitoring and Evaluation Directorate
RADU	Regional Agricultural Development Unit

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INTRODUCTION

Ghana's agricultural sector has achieved rapid production growth since the early 1990s and has contributed greatly to the country's impressive economic transformation. However, sustained agricultural growth is not assured, and several important constraints are emerging. Cereal crop yields remain low and are rising very slowly over time. Use of inorganic fertilizer is low even by African standards -- 8 kgs per hectare on average -- in contrast to the Abuja Declaration target of 50kgs per hectare. It is widely agreed that increased use of inorganic fertilizer is crucial to achieving sustainable agricultural productivity growth.

Current policy efforts are focused on lowering the cost of fertilizer to farmers in order to increase its use. These efforts alone may increase the usage of fertilizer without necessarily improving agricultural productivity, due to the very low efficiency with which many farmers use fertilizer. For example, survey evidence from Ghana indicates widely varying maize response rates to nitrogen fertilizer application; responses in the range of 5-20 kgs maize per kg N are not uncommon. These estimates are in line with survey evidence on fertilizer response rates obtained on farmer-managed fields from many countries in the region (Table 1). By contrast, on-farm trials using best practice approaches tend to be at least double the response rates show in Table 1, indicating substantial scope for increasing the efficiency with which farmers use fertilizer if they are capable of overcoming the many constraints that currently prevent them from adopting these practices.

In much of Africa, including many areas of Ghana, achieving much higher levels of fertilizer use is inhibited by low crop response rates to fertilizer application, which depress farmers' incentives to use fertilizer and erode the contribution of increased fertilizer use through subsidy programs to national development goals. It is increasingly understood that crop response to inorganic fertilizer in many areas of Africa, including Ghana, are depressed by a variety of soil degradation problems. Soil fertility management is a crucial yet under- appreciated dimension of sustainable productivity growth. If soil fertility problems remain unaddressed, Ghana's agricultural growth will be impeded, its agricultural lands will become increasingly degraded, its use of inorganic fertilizer will continue to be low, and it is likely to become more dependent on food imports as the rate of growth of population or consumption outstrips that of food production.

Table 1. Recent estimates of fertilizer application and crop response rates in sub-Saharan Africa

African study areas	*Geographic focus*	*% maize fields receiving commercial*	*Application rate for users*	*Estimated nitrogen use efficiency (kgs output per kg N)*	*VCR*
Sheahan *et al* (2013)	20 districts of Kenya where maize is commonly grown, 5 years of data between 1997-2010.	Ranges from 64% (1997) to 83% (2007)	26 kg N/ha (1997) rising to 40kg N/ha (2010)	AP=21 kg maize/kg N MP=17 kg maize/kg N	AVCR=Ranging from 1.3 (high-potential maize zone) to 3.7 (eastern
Marenya and Barrett (2009)	Kenya (Vihiga and S. Nandi districts); relatively high-potential areas	88% (maize and maize/bean intercrop)	5.2 kg N/ha	MP=17.6kg maize/kg N	MVCR=1.76 (but fertilizer was <1.0 on 30% of plots).
Matsumono and Yamano (2012)	100 locations in Western and Central Kenya (2004, 2007)	74%	94.7 kgs fertilizer product/ha maize	MP=14.1 to 19.8kg hybrid maize/kg N	MVCR=ranging from 1.05 to 1.24 for hybrid maize
Snapp et al (2014)	Malawi – nationally representative LSMS survey data	27% (maize plots)	62.9 kgs/ha maize	5.33 for monocropped maize; 8.84 for intercropped maize	
Morris *et al* (2007)	W/E/S Africa			E/S Africa: 14 kgs maize/kg N (median) W. Africa: 10kg maize/kg N (median)	E/S Africa: 2.8 W.Africa: 2.8
Minten, Koru, Stifel (2013)	Northwestern Ethiopia	69.1% of maize plots fertilized	65.3 kg N/ha	MP=12kg maize/kg N on- time planting; 11 kg maize/kg N for late planting	1.4 to 1.0 (varying by degree of remoteness)
Pan and Christiaensen (2012)	Kilimanjaro District, Tanzania			11.7 kg maize/kg N	
Xu *et al* (2009)	AEZ IIa in Zambia (relatively good quality soils/rainfall suitable for maize	56.4% on maize	61.4 kgs N/ha (among users)	AP=18.1 (range from 8.5 to 25.5) MP=16.2 (range from 6.9 to 23.4)	Accessible areas=1.88
Burke (2012)	Zambia (nationally representative), 2001, 2004, 2008	36-38% of maize fields; 45-50% of maize area	35.2 N/ha maize	9.6 kg maize/kg N	0.3 to 1.2 depending on soil pH level for 98% of sample
Ricker-Gilbert and Jayne (2012)	Malawi, national panel data	59% of maize fields	47.1 N/ha maize	8.1kg maize/kg N	0.6 to 1.6
Chibwana et al (2012)	Malawi – farmer-managed field data in Kasumgu and Machinga Districts			9.6 to 12.0kg maize per kg N	
Chirwa and Dorward (2013)	Malawi – national LSMS survey data			Negative to 9.0	Below 2.0
Liverpool-Tasie et al (2015)	Nigeria – national LSMS survey data			8.0kg maize/kg N 8.8 kg rice/kg N	Below 2.0 Below 2.0

Sources: see reference section for complete citations.

The objectives of this report are:

i. to explain the causes and consequences of soil degradation in hindering the Ghanaian government's agricultural and broader economic development goals;
ii. to identify other market and institutional factors influencing fertilizer use, particular for maize and cocoa; and,
iii. to identify concrete actions that the government may wish to consider to achieve more sustainable agricultural productivity growth.

The methods rely on reviews of existing reports, many by Ghanaian scientists and academics; information obtained from key informant meetings with stakeholder groups, including fertilizer importers and distributors, farmers and representatives of farmer organizations, scientists, development partners, and government officials. The report is also based on primary analysis of farm survey data sets, GLSS data, and Ministry of Food and Agriculture statistics.

The layout of the report is as follows:

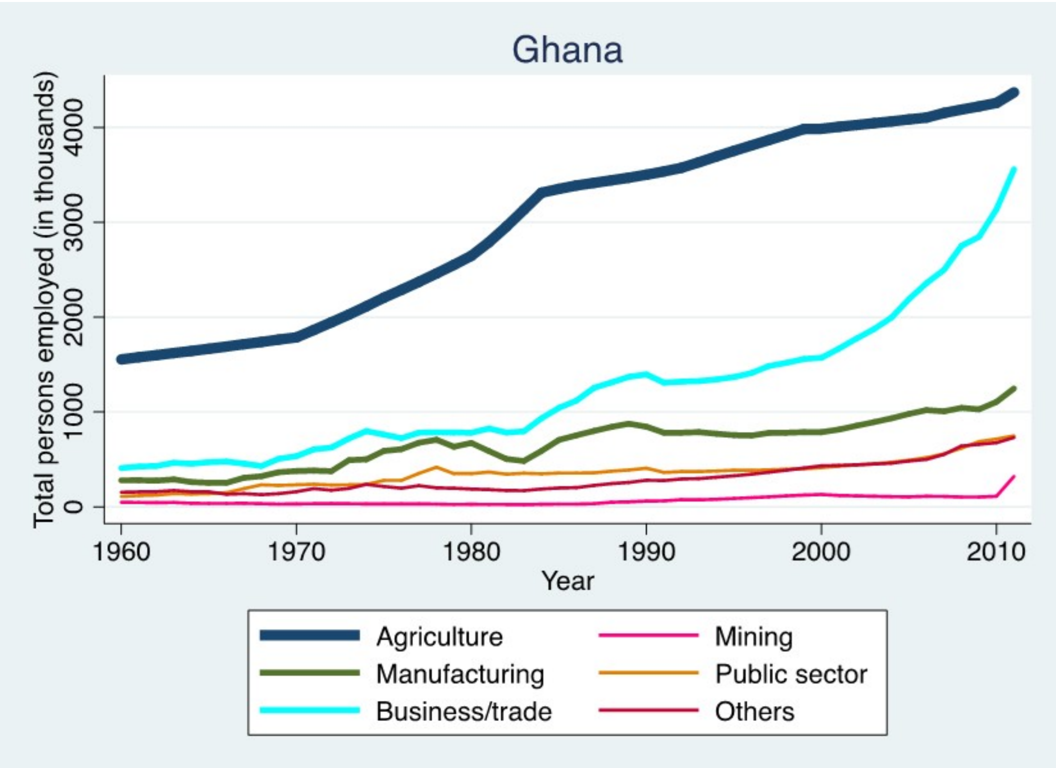
- Section 2 briefly covers important trends in Ghana's agricultural sector that are relevant to our objectives.
- Section 3 describes Ghana's soil characteristics, reviews the causes and extent of soil degradation in the country's varied agro-ecologies and reviews the evidence of soil degradation on the crop response rates that farmers obtain when using inorganic fertilizer.
- Section 4 examines the institutional and market-related impediments to expanded fertilizer use in Ghana, with particular focus on the maize and cocoa sectors.
- Section 5 identifies elements of a holistic strategy to achieve sustainable agricultural productivity growth.
- Section 6 summarizes the main points and identifies a number of actions for consideration by the government.

TRENDS IN GHANA'S AGRICULTURAL SECTOR

The agricultural sector of Ghana contributes about 21% (2014) to the country's gross domestic product (GDP), employs over half of the labour force and also provides raw materials for industrial growth and development (GoG, 2010). The GDP growth rate was 4.4%, while that of the agricultural growth rate was 4.2% in the year 2000 – 2003. In 2003 – 2007, the GDP growth rate increased to 5.8%, while that of the agricultural growth increased to 5.2% (ISSER, 2008). From 2006 until 2014 the GDP increased on average by 8.21%, while the agricultural sector grew by 4.14% (GSS, 2015).

The majority of Ghana's population has historically been engaged in agriculture (figure 1). Farming will continue to be the single largest source of employment for Ghanaians for at least another decade, though Ghana's economy is diversifying rapidly. Micro businesses, services, construction, manufacturing and mining are growing fast. These indications of structural transformation are very positive and have been fuelled by the multiplier effects from sustained agricultural growth starting in the 1990s. Economic transformation in Ghana will continue to be influenced by the pace of agricultural labour productivity growth.

Figure 1. Employment trends in Ghana



Source: Groningen Global Centre for Development employment files (2013)

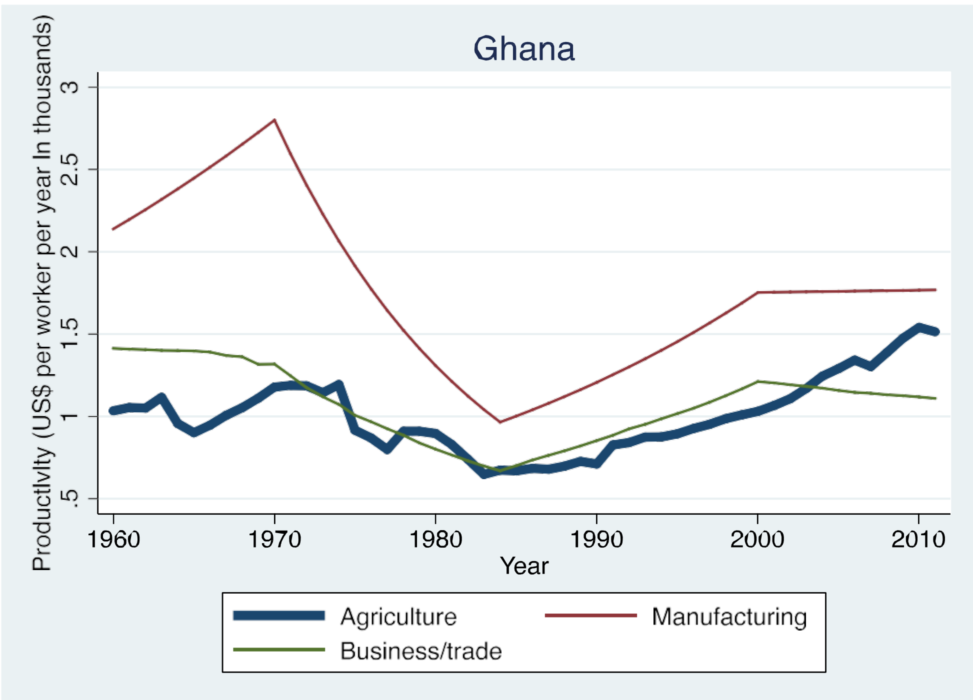
The following basic identity (Equation 1) shows that labour productivity in agriculture (the net value[1] of agricultural output divided by agricultural labour, Y/L) is determined by the product of two terms: land productivity or the net value of agricultural output per unit of cultivated land (Y/A) and the ratio of cultivated land to labour (A/L).

$$\frac{Y}{L} = \frac{Y}{A}\frac{A}{L} \qquad (1)$$

We focus on labour productivity in agriculture because it is normally considered to be the closest reflection of livelihoods for those engaged in agriculture. Equation 1 shows that raising labour productivity in agriculture will require major growth in land productivity (Y/A) and/or an increase in the rate of area expansion compared to the agricultural labour force.

In many African countries, labour productivity in agriculture has risen in recent years as land productivity (Y/A) growth rates have started to exceed the decline in the ratio of cultivated area to agricultural labour (A/L). Ghana's economic success over the past several decades has benefited greatly from rising labour productivity in agriculture since the early 1990s (Figure 2). The country has experienced a decline in the share of the labour force in agriculture from 65% to 45% in the past two decades, which has exerted downward pressure on A/L and contributed to labour productivity growth as per Equation 1.

Figure 2. Labour productivity ('000 USD per worker per year) by sector, Ghana



Source: Groningen Global Centre for Development files

[1] Net value refers to the value of crop production minus the cost of all inputs use to produce the crop.

But Ghana's labour productivity in agriculture would be much higher than it is today if greater use of inorganic fertilizer could have raised net output per hectare (Y/A). While greater use of fertilizer should also be a natural outgrowth of a more productive agricultural system, fertilizer use in Ghana remains very low at 8kgs per hectare cultivated. Sustained agricultural productivity growth is likely to require much greater use of fertilizer, and relatedly, more efficient use (Dittoh et al, 2012). As will be shown in more detail below, raising inorganic fertilizer use in Ghana will require greater attention to the soil-related factors that influence the crop response rates that farmers are currently obtaining from the use of fertilizer.

Fertilizer use trends

Fertilizer use in Ghana since 2010 is 6 to 10 times higher than it was in the early 2000s. The Fertilizer Subsidy Programme (FSP), which started in 2008, has had a lot to do with this, accounting for roughly 40% of total fertilizer use during the 2011 to 2013 period (Table 2). In 2012, Ghana imported more fertilizer than any country in sub-Saharan Africa except Ethiopia, Nigeria and South Africa.

The stated objectives of the FSP are to increase farmers' accessibility to inputs and also raise application rates from current average of 8kg/ha to at least 20kgs/ha and therefore raise farmers' incomes. The main fertilizers subsidized are NPK (15:15:15), Urea, and SOA targeting mostly maize, rice, millet, sorghum, and horticultural crops.

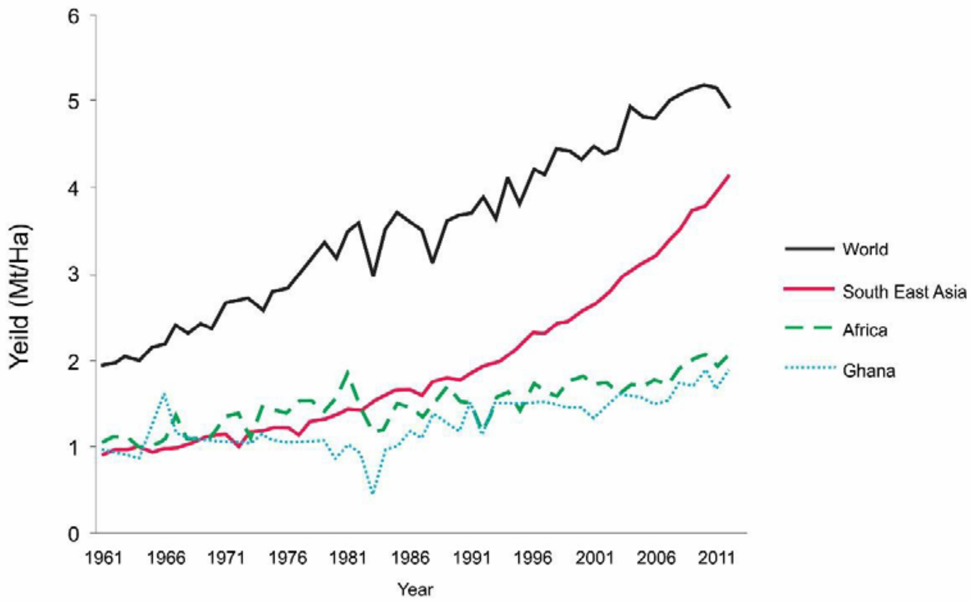
One would think that the substantial increase in fertilizer use since 2009 of the magnitude shown in Table 2 would have had a major impact on agricultural productivity. However, there appears to have been only a modest increase in food crop yields since 2011 when fertilizer imports increased dramatically associated with the commencement of the FSP. As shown in Figure 4, maize yields in Ghana have continued to rise slowly at long-term trend growth rates, and show no obvious jump during the post-2008 FSP period compared to the pre-2008 trend. Meanwhile, maize yields in other regions of the world continue to rise rapidly. Increased food production in Ghana is presently due mostly to expansion of area under cultivation. Average yields of most of the crops are 20% - 60% below their achievable yields, indicating that there is significant potential for improvement.

Table 2. Trends in fertilizer use, prices and profitability of use in Ghana

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total Fertilizer imports (mt)	41,888	92,807	223,733	91,306	189,879	189,594	187,030	335,186	489,215	432,343	669,951	371,012
Fertilized distributed under FSP (mt)							43,176	72,795	91,244	176,278	173,755	180,000
Total FSP (% of total imports)							23.1	21.7	18.7	40.8	25.9	48.5
Total expenditure on the agriculture sector (GHS	34.4	44.8	69.8	106.5	122.9	169.9	305.3	363.6	442.2	576.2		
Total expenditure of MOFA (GHS million)	5.4	7.7	10.0	42.3	35.2	47.4	102.4	145.5	160.0	241.8		
Total FSP (GHS million)							20.7	34.4	30.2	78.7	117.4	64.0
Total FSP (% of total agriculture expenditure)							6.8	9.5	6.8	13.7		
Total FSP (% of total MOFA expenditure)							20.2	23.6	18.9	32.5		
FSP announcement date							2-Jul	9-Apr	21-Jul	11-May	4-Jun	16-Apr
Market price (GHS/50kg bag)												
NPK 15:15:15 -mkt price			18.9	20.2	20.4	21.7	38.1	43.4	44.0	42.0	42.0	49.0
SOA - mkt price			14.2	15.8	17.5	18.1	28.1	33.0	34.0	33.0	40.0	44.0
Urea - mkt price			18.9	22.9	24.6	25.8	36.0	47.0	41.0	43.0	44.0	54.0
FSP subsidy price (GHS/50kg bag)												
NPK 15:15:15 - FSP price							26.0	26.0	27.0	30.0	39.0	51.0
SOA - FSP price							18.0	18.0	18.0	26.0	38.0	44.0
Urea -FSP price							26.0	26.0	25.0	29.0	35.0	50.0
Average Ghana farm-gate price (GHS/metric tonne)						238	318	347	291	366	710	831
Value cost ratio (VCR) of urea fertilizer at market prices used on maize												
at response rate of 4 (12 kgs maize per kg N)						1.84	1.77	1.48	1.42	1.70	3.23	3.08
at response rate of 5 (15 kgs maize per kg N)						2.30	2.21	1.85	1.77	2.13	4.03	3.85

Sources: Fertilizer imports: IFPRI. Fertilizer market prices are those for April-June of each year, MOFA-SRID data files. Maize farm-gate prices for each year: Ghana Statistical Service and MOFA-SRID.

Figure 3. Average maize yields



Source FAOStat, 2014

Inorganic fertilizer does not necessarily improve agricultural productivity in isolation of other yield-enhancing technologies and practices (Vanlauwe et al., 2011). It is well established that complementary investments in soil and water conservation for efficient and optimal nutrient uptake is crucial, especially on degraded soils, not only to raise the profitability of fertilizer use but also to achieve a sustainable agricultural system.

One of the most important soil augmenting investments that complements inorganic fertilizer is organic forms of fertilizer, such as compost, manure, and other sources of organic matter (Tittonell and Giller, 2013; Vanlauwe et al., 2011). The proportion of Ghanaian farm households using inorganic fertilizer is approximately 33 percent, although there is major variation across the country. Less than 2 percent of farmers use both organic and inorganic fertilizers. For sustainable agricultural intensification and productivity growth, it is the combination of both organic and inorganic fertilizers that increases crop response rates to inorganic fertilizer and thereby makes inorganic fertilizer more profitable to use (Snapp and Grandy, 2011). The joint adoption of inorganic and organic fertilizer is also the foundation of a sustainable agricultural productivity growth strategy (Shaxson and Barber, 2003; Powlson et al., 2011).[2]

Table 3. Percent of Households Using Organic and Inorganic Fertilizer

		Inorganic Fertilizer Adoption	
		Yes	No
Organic Fertilizer Adoption	Yes	1.8%	12.2%
	No	31.2%	54.8%

Source: GLSS VI (2012/2013).

Data in Table 2 provide a rough estimate of the profitability of using urea fertilizer on maize. The 'value/cost ratio' (VCR) is an indicative measure of the profitability of using fertilizer. It is computed as the ratio of the farm-gate price of maize to the cost of acquiring fertilizer, multiplied by the additional maize produced from an additional kilogram of fertilizer applied to the maize field. Studies have shown that VCRs in excess of 2.0 are generally required for smallholder farmers to demand fertilizer on a sustained basis (Crawford and Kelly, 2002).

While definitive studies of crop response to fertilizer in Ghana are unavailable, agronomic response rates of 8 to 16 kilograms of maize per kg nitrogen are typically observed on farmer-managed fields in most parts of the region as shown in Table 1 (see also Jayne and

Rashid, 2013, and Snapp et al., 2014 for reviews of the literature). Using agronomic response rates of 12 to 15, and given prevailing maize and fertilizer prices in Ghana as reported by the Ministry of Food and Agriculture and shown in Table 2, we compute VCRs for the 2007-2013 period. The VCRs reported in Table 2 are mostly below 2.0 for the 2007-2011 period but rose substantially above this level in 2012 and 2013, when maize prices were relatively high compared to the other years. While these results are only indicative and more detailed site-specific analysis of fertilizer profitability is required, the use of available information suggests that using fertilizer on maize may not be profitable for many Ghanaian farmers given full market

[2] The importance of supporting African farmers to raise their use of both organic and inorganic fertilizers was also stressed in the Abuja Declaration of 2006.

fertilizer prices, prevailing maize prices, and average agronomic response rates observed on farmer-managed fields from similar agro-ecologies in the region. The significant rise in VCRs in the two most recent years is encouraging, as it indicates increased profitability and demand for fertilizer, and is most likely influenced by relatively high maize prices during 2011-2013. However, the ability of Ghanaian farmers to use higher levels of fertilizer profitably, consistently, and productively will depend on efforts to raise farmers' response rates to fertilizer application.

SOIL FERTILITY CONDITIONS IN GHANA[3]

The total land area of Ghana is 23,853,900 ha of which 57.1% (13,628,179 ha) is suitable for agriculture but most of the soils are of low inherent fertility. The coarse nature of the soils has an impact on their physical properties and water stress is common during the growing season. Extensive areas of country's land area particularly the Interior savannah zone have suffered from severe soil erosion and land degradation in various forms. Ghana has one of the highest rates of soil nutrient depletion among sub-Saharan African countries with annual projected losses of 35 kg N, 4 kg P and 20 kg K ha^{-1}. The extent of nutrient depletion is widespread in all the agro-ecological zones with nitrogen and phosphorus being the most deficient nutrients. Nutrients removed from the soils by crop harvest have not been replaced through the use of corresponding amounts of plant nutrients in the form of organic and inorganic fertilizers.

While Ghana has one of the highest soil nutrient depletion rates in SSA, it has one of the lowest rates of annual inorganic fertilizer application - only 8 kg per hectare. Therefore, even compared to most other African countries with fragile soils, sustainable forms of agricultural intensification in Ghana will require explicit attention to soil nutrient replacement.

While there has been considerable research and policy analysis on fertilizer use in Ghana, there remain knowledge gaps, on the state of fertility of Ghanaian soils; the yield response to fertilizer for major crops, the profitability of fertilizer use, and the likely effects of changing climatic conditions on the profitability of fertilizer use.

Most of Ghana's soils are developed on thoroughly weathered parent materials. They are old and have been leached over a long period of time (Bationo, 2015). Their organic matter content is generally low, and are of low inherent fertility. The two most deficient nutrients are nitrogen and phosphorus particularly because of the very low organic matter content. The build-up of any amount of organic matter is further constrained by the regular burning of crop residue and/or competitive use of these residues for fuel, animal feed or building purposes.

The low vegetative cover during the long dry season also renders most of the soils susceptible to erosion during the rainy season. This, in turn, exacerbates the low fertility problem. The sustainability of good crop yields is therefore closely linked with the careful management of the soils with the objective of preventing and controlling erosion, increasing their organic matter content, and replacing and increasing plant nutrients lost through erosion and crop uptake. The average fertility status of soils of the different agro ecological zones is presented in Table 4.

[3] This section draws from Bationo (2015).

Table 4: Soil Fertility Status of the Various Agro-ecological zones

Agro-Ecological Zones	Soil pH	Organic C (%)	Total N	Available P (mg/kg soil)	Available K
High Rainforest	3.8 – 5.5	1.52 – 4.24	0.12 – 0.38	0.12 – 5.42	63.57 – 150.41
Forest-Transition	5.1 – 6.4	0.59 – 0.99	0.04 – 0.16	0.30 – 4.68	58.29 – 72.53
Semi-Deciduous Forest	5.5 – 6.2	1.59 – 4.80	0.15 – 0.42	0.36 – 5.22	62.01 – 84.82
Coastal Savanna	5.6 – 6.4	0.61 – 1.24	0.05 – 1.16	0.28 – 4.10	48.02 – 58.71
Guinea Savanna	6.2 – 6.6	0.51 – 0.99	0.05 – 0.12	0.18 – 3.60	46.23 – 55.27
Sudan Savanna	6.4 - 6.7	0.48 – 0.98	0.06 - 0.14	0.06 – 1.80	36.96 – 44.51

Source: Bationo, 2015

The major processes or types of soil degradation in Ghana are physical (erosion, compaction, crusting and iron pan formation), chemical (depletion of nutrients, salinity and acidification) and biological (loss of organic matter).

Soil erosion

Soil erosion caused by rainfall and water runoff is one of the most potent degradation processes affecting soil productivity. Large tracts of land in Ghana have been destroyed by water erosion (Quansah et al., 2000). Studies by Asiamah (1987) on the extent of erosion reveal the land area susceptible to the various forms of erosion as 70,441 km2 to slight to moderate sheet erosion, 103,248 km^2 to severe sheet and gully erosion and 54,712 km^2 to very severe sheet and gully erosion. The most vulnerable zone is the northern savannah (Guinea and Sudan Savannah zones) which covers nearly 50% of Ghana with the Upper East Region being the most degraded area of the country.

A model of land degradation assessment in Ghana predicts that land degradation reduces agricultural income in Ghana by a total of US$4.2 billion over the period 2006–2015, which is approximately five percent of total agricultural GDP in this ten-year period (Diao and Sarpong, 2011).

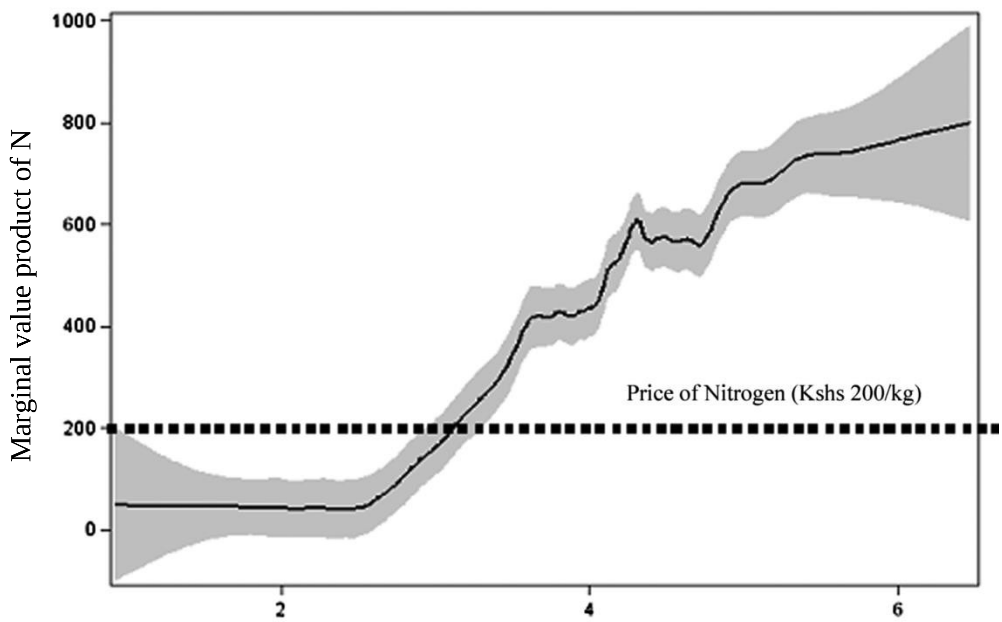
Nutrient depletion

Loss of nutrients, including organic matter, is the key contributor to chemical soil degradation. Nutrient depletion occurs primarily through crop removal in harvested products and residues, leaching, erosion and N volatilization. Stoorvogel and Smaling (1990) showed that nutrient losses through these depletion pathways are only partially compensated for by crop residues left on the field, manure and fertilizer application besides atmospheric inputs. Consequently the annual NPK balance for sub-Saharan Africa were negative with minus

22 – 26 kg N, 5.83 – 6.87 kg P_2O_5, and 18 – 23 kg K_2O ha^{-1} from 1983 – 2000.

In Ghana, annual depletion rate of 30 kg N, 3 kg P and 17 kg K h^{-1} were recorded for the period 1982 – 84. The projected figures for year 2000 were 35 kg N, 4 kg P and 20 kg K ha^{-1}. Of course this was a special period, perhaps isolated, in Ghana's history when the country experienced long spells of dry weather leading to vast bush fires across the country. The extent of nutrient depletion in Ghana is widespread in all the agro-ecological zones with nitrogen and phosphorus being the most deficient nutrients. These deficiencies are, however, more pronounced in the coastal, Guinea and Sudan Savannah zones where organic matter content is low and the annual burning[4] and removal of crop residues further prevent the build- up of organic matter. It has also been generally observed that the eroded sediments contain higher concentrations of organic matter and plant nutrients in available forms than the soil from which these were lost (Quansah et. al., 2000).

Figure 4. Estimated marginal value product of nitrogen fertilizer conditional on plot soil carbon content, Western Kenya.



Source: reproduced from Marenya and Barrett (2009)

The high losses of organic matter are of particular concern since nutrients applied to the soil in the form of mineral fertilizers are far less effective on soils with low organic matter content (Swift, 1997; Tittonnel and Giller, 2013; Snapp et al, 2014). Figure 4 shows the relationship between soil organic carbon and maize response to nitrogen from inorganic fertilizer in Kenya. This figure, as with recent research from other parts of Africa, shows a threshold level of soil organic carbon (found to be roughly 0.8 by previous studies), below which inorganic fertilizer produces very little crop response (Snapp et al., 2014). Table 2 above shows that many areas of Ghana have soil organic carbon levels that are below this 0.8 threshold, particularly in the Forest Transition, Guinea Savannah and Sudan Savannah regions. Figure 4 shows a much higher threshold SOC level of roughly 3.0 for the particular location in Western Kenya. Most agronomic studies indicate a much lower threshold level.

Water logging

In the Guinea and Sudan Savannah Zones (GSSZ), localized water logging is experienced every rainy season. This is mainly due to shallow soils, high rainfall intensities and poor surface drainage resulting from the general low relief of the terrain. Peak season floods are major cause

[4] Control and Prevention of Bushfires Act, 1990 articulates rules for burning within and without conservation area, including range management (means the control and manipulation of vegetation for optimum usage by human beings, livestock or wild animals according to the Act). However, the farmers we interviewed claimed that often bushfires extend beyond controlled regions. This may suggest that the 1990 Act is not being implemented/enforced to its full extent. The government has indicated a possible review of the law to increase the role of traditional leaders in enforcement

of recurrent crop failures and food shortages. In the Coastal Savannah Zone (CSZ), the low infiltration rates of Vertisols, the subdued relief and high rainfall intensities are responsible for periodic water logging which causes crop failure.

Land Tenure Arrangement

A key factor affecting land management and soil quality in many areas of Ghana are prevailing land tenure arrangements. The type of land tenure arrangements more often than not make farmers indifferent to the loss of future economic returns to land. Sharecroppers have put enormous pressure on soil fertility to realize immediate high yields in order to pay land rents (Benneh et al., 1997). Farmers in such situations discount the future at very high rates, thereby reducing the incentive for long-term investments in improved soil fertility. For example, the team found anecdotal evidence that lack of access to land is restricting entry of youth into cocoa farming, and that the risk of losing land rights or renegotiating land tenure may discourage settler farmers from removing diseased trees from farms.

Demographic pressures and land availability constraints have also contributed to the decline in soil fertility. With increasing populations, the traditional techniques for renewing soil fertility, such as slash-and-burn and long-term fallowing, are not as feasible as they once were. The need for subsistence production and income are such that land can no longer be taken out of production for substantial periods to allow for natural nutrient replenishment. Nor are animal manures and crop residues usually sufficient for replacing lost nutrients.

Other traditional soil fertility management techniques also generally fall short of the nutrient requirements of today's intensive agricultural practices. Majority of farmers in Ghana generally do not have the resources to produce sufficient organic fertilizers to replace all the nutrients removed at harvest time. For example, in order to provide 150 kg of plant nutrients to fertilize one hectare of land, a farmer could apply either 200 kg of inorganic NPK fertilizer, or 10 to 15 metric tons of crop residue grown on 5 to 10 hectares of land, or 18 metric tons of animal manure generated from crop residue grown on 10 to 15 hectares of land (Bationo, 2015).

Elements of a strategy to achieve sustainable agricultural productivity growth

While the Government of Ghana's efforts to raise fertilizer use is laudable, GoG expenditures on input subsidy programs currently appear to produce relatively limited benefits for farmers because crop response rates are low. The contribution of the input subsidy program (and fertilizer use in general) to sustainable growth could be much greater if the soil-related constraints on agricultural productivity were addressed through a holistic program of soil fertility management. The general elements of such a holistic program are as follows:

- **public sector research programs** to identify region-specific best practices for amending soil conditions, given the great micro-variability in agro-ecological conditions in the country

- **public agricultural extension programs** to transfer region-specific best practices to farmers as well as provide bi-directional learning between researchers and farmers to refine best practices in light of farmers' experiences in their fields, and

- **input distribution systems** that make available the full range of products and services required by farmers. Input distribution systems for a wider set of soil enhancing products, such as organic fertilizer, lime, and new lines of inorganic fertilizer (e.g., deep placement, slow release types, etc.), will be developed once there is proven effective demand for such products. Developing the effective demand will in turn require research to determine site-specific soil diagnostics and best practices, and then extension systems that effectively link farmers to researchers to guide bi- directional learning and adaptation of technologies and practices. The point is that input distribution systems do not develop spontaneously – they typically require the prior public investments required to generate effective demand among farmers for new inputs.

- **public support services,** e.g., the Ghana Cocoa Board (Cocobod), that effectively provides collective action (such as comprehensive area spraying to arrest pest and disease problems in cocoa producing areas) in cases where individual farmer behaviour cannot produce favourable outcomes.

To move from general thrusts to concrete steps, the following proposals are offered for government consideration.

1. Provide support to existing research institutions in each of Ghana's diverse agro-ecologies and regions to develop "best practices" with regard to crop and soils management for particular crops and regions. Site-specific recommendations on best practices require a better understanding of the factors that might constrain productivity. Soils maps need to be updated to reflect soil functional properties (rather than soil taxonomic class) as well as more spatial detail on the variation of these functional soil properties. There already exist initiatives that can be built on for this purpose (e.g. the AfSIS project). Affordable techniques are available for wide-scale soil testing and analyses. Building the capacity to conduct wide-scale soil testing services in Ghana would provide an important foundation to provide farmers with improved knowledge of how to manage their soils and improve their incomes from farming.

2. Benchmark landscapes would need to be identified and characterized in terms of their current soil fertility status (and variability herein) by means of multi-locational diagnostic trials. Diagnostic trials give insight into the actual soil health constraints and means to overcome apparently large yield gaps. Linking the constraint envelopes to particular landscape positions will help to map soil health constraints for the wider landscape.

3. Based on the diagnostics trials 'best bet' soil management practices to address the observed soil health constraints can be identified. Local extension services could then provide soil management recommendations that would include nutrient management options in combination with other soil amendments for the various crops, and using improved varieties, aiming to improve the agronomic efficiencies of the fertilizer use, which would in turn raise the demand for fertilizer.

4. Extensive testing of the recommended soil management practices on farmer's fields will allow local research institutes to determine crop response to the various inputs and would support the formulation of recommended input packages to raise farmers' expected returns to investment. Use of locally available (organic) resources should be considered as part of the solution. This will involve the collection, collating and analyzing existing secondary data and primary data, and use of appropriate crop and soil fertility models.

5. A review of available information on the existing mineral fertilizers and its use under the current agro-ecological conditions provides the basis for further research on fertilizer product development (to achieve balanced crop nutrition) and formulation of alternative soil fertility management strategies for the various agro-ecological conditions, land degradation status and farm type. Extensive field demonstrations and extension guides may be needed in support of a more site specific recommendations.

6. Science-based monitoring and evaluation of yields on the fields of farmers who have adopted the recommended practice should allow for gradual development towards a 'best-fit' solution that reflects the farmer's socio-economic situation. There are advanced ICT tools available that can be used for data collection. Such approach would require reform of the extension services and better collaboration with already existing rural development initiatives and with the research community.

In addition to these proposals, which focus on developing the country's agricultural research and extension systems' capacity to meaningfully support farmers, interviewed stakeholders frequently mentioned the following additional issues that could promote sustainable agricultural productivity growth in Ghana:

7. *Implement the Fertilizer Subsidy Program in ways that promote transparency and reduce uncertainty among farmers and input distributors*

Existing inconsistencies and uncertainties regarding whether subsidies would be provided or not is hampering the ability of actors including farmers, importers, input dealers and distributors to adequately plan for the season. It was noted that the announcement of the FSP in recent years has come very late, never before April and as late as July in 2008 and 2010. Such delays in program announcement contribute to delays in fertilizer delivery to farmers and the untimely application of fertilizer, which reduces response rates and the contribution of fertilizer to food production.

8. *Modify the modalities of FSP distribution to enhance efficiency*

Under the waybill system, fertilizer distribution companies import and pay all costs to deliver fertilizers to their assigned regions or districts from where their network of agro-dealers sell to farmers. The stocks delivered to districts are confirmed by MOFA staff and payment to importers is made on quantity (bags) of fertilizer sold. Therefore the signed / verified sale documents have to be channeled back to importers for the latter to claim their refunds from the designated government secretariat. This program faces some of the same problems as the previous voucher program, including the late delivery of fertilizers and delays in reimbursing importers and distributors by the government, thereby increasing the costs involved in fertilizer trade (Fuentes et al., 2012). A number of inefficiencies emanate from the rigidity brought into the system by fixed transport costs and margins for the market players. This gives no room for flexibility for players with changes in exchange rates or varying distances to farms and related costs, leading to the classic case in which dealers sell only at large rural centers and avoid distributing to remote places. Thus the implementation of the subsidy program restricts the development of retail networks in rural areas. This structure of controlled prices implies that market penetration will be limited, and some areas will not be served, as they do not offer attractive returns to traders within these restrictions. A proposal for consideration is to modify the fixed transport cost margins for distribution firms as a function of the points to which they deliver. This modification would promote access to FSP fertilizer by farmers in more remote areas.

9. *Government should liaise with local community leaders to implement strategies to address bush fire*

The stakeholders that the study team consulted with felt that bush fires were a major contributor to the current low levels of organic matter in farmers' fields. In addition to its threats to human life and property, uncontrolled bush fires consume vegetation cover and crop residues on agricultural land, and undermine nutrient recycling to improve soil fertility. Inadequate enforcement of bush fire laws (PNDCL 2 29) at the national level inhibits efforts to curb widespread and pervasive bushfires across the country, which also frustrates sustainable soil management strategies. Evidence suggests that community level strategies (e.g. establishment of bush burning free zones in Nandom Traditional Area in Northern Ghana) are successful at enforcing rules and reducing rates of bush fire. In light of this, we recommend that local authorities (e.g., District Assemblies) sensitize their constituents and develop modalities to implement bush fire prevention programs at community level as a means to safeguard life and properties, and boost organic matter content in the soil.

9. *Domesticate the ECOWAS Fertilizer Quality Regulations to protect farmers*

The ongoing efforts by GoG and other stakeholders to identify what needs to be done to make sure that farmers access quality fertilizer should be encouraged. It is necessary to identify areas that need strengthening in terms of infrastructure and human capacity in order to adapt the regional regulatory framework signed by ECOWAS in 2012. This is an important aspect in making sure that farmers access fertilizers with the correct nutrient content which has implications for crop response rates.

10. *Facilitating private sector entry and investment in agricultural input distribution*

Government actions influence the rate of private sector investment in fertilizer value chains and hence influence farmers' access to agricultural inputs. The following issues illustrate the complex ways in which government actions affect market access conditions for farmers:

Access to Capital: Access to affordable capital is one of the most important factors influence private entry and investment in the agricultural sector. In Ghana specifically and Africa more generally, commercial banks generally do not lend to private agricultural input distributors and retailers, often citing the following problems that create high risks of loan non- repayment: (i) lack of verifiable information about the proposed borrowers; (ii) climate risks (drought and flood); (iii) insufficient credit guarantee from government and donors; (iv) potential opportunistic behavior of retailers, who sometimes do not pay back their loans to the input distributors who supply them; and (v) unpredictability of government policies in input markets. Overcoming these constraints on access to capital will require systemic improvements in the functioning of agricultural commodity, input and finance markets, and are therefore likely to remain major problems at least in the short run.

Storage Facilities: Related to the lack of working capital is the problem that fertilizer distributors are sometimes unable to secure storage space. While the availability of physical storage facilities is most likely not a major problem, many private stakeholders are able to invest in urgently needed warehouse space for lack of working capital. Expanded access to credit will enable distributors to reduce their transport expenses by reducing trips to the Tema port where the importers' warehouses are located, and thereby promote competition in input distribution.

Ideally, one or two fertilizer wholesalers might be in a position to consider building warehouses up to 60-80KMT in either the Ashanti or Brong Ahafo regions. By so doing, those facilities could act as inland port and allow the Northern Region distributors to forgo transport costs from the Tema port. Private firms' willingness to make such investments will depend on their assessment of the enabling environment over the next 5-10 years.

Better credit terms with importers: To facilitate the downstream flow of fertilizer, the large importers might consider improving their credit and payment terms to local distributors. Under most current agreements, a well-performing distributor may have a credit limit of $300K and 30-days repayment. That credit amount and repayment period may prove difficult for many distributors to adhere to, thereby increasing trader costs and restricting the number of distributors operating in local markets.

When a distributor is unable to repay within the 30-day limit, he or she has to resort to a commercial line of credit (if possible) with an average of 32% annual interest at financial institutions. Otherwise, the distributor must request credit from microfinance lenders at 4-7% monthly interest.

Some importers are concerned that with the upcoming IMF US$ 940 million 2015-2017 bailout, oil revenue shortfall, huge compensation bill, and current cedi devaluation, the Government may not be able to fulfill its financial obligations towards them in the subsidy programs.[5] Already, some large companies have withdrawn from participation in the Government's input subsidy program.

Linking farmers to market: One possible solution to the high borrowing costs is linking farmers to market by leveraging outgrower schemes and identifying readily available and solvent buyers. Under that scenario, an agro-processor or commodity exporter could pre- finance input purchase with a distributor on behalf of smallholder farmers. The payment could be made directly to the importer, who would then provide the distributor a commission per bag upon delivery. By so doing, the lack of credit and pressure to borrow at high interest rates would have been relieved for those stakeholders who could join such scheme.

Interviewed private companies often provided the following as examples that could be pursued to improve the functioning of agricultural input markets in Ghana:

- Banking policies with easy-to-access and well-funded credit guarantees (at least US$50 million)
- Capacity building for the fertilizer stakeholders (e.g., hub agrodealers training on inventory and cashflow management)
- Removal of unnecessary road checks to reduce transport costs and facilitate timely delivery
- Timely advance announcement of the details of government subsidy program logistics (quantities to be distributed, modalities of distribution, distributors to be involved, locations of program operation, fertilizer types, etc).

A full listing of these proposals, divided into short-term, medium-term and long-term actions are presented in Appendix Tables 1, 2 and 3.

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[5] For example, during the week of March 16-20, 2015, multi and bilateral partners decided to withhold US$700 million of promised foreign aid. Facing such a gap, the Minister of Finance consequently revised the budget downwards by Ghana cedis 1.5 billion. Such developments create risks for financial institutions considering lines of credit to agricultural input suppliers participating in government subsidy programs.

SUMMARY

Most efforts to raise fertilizer use in SSA over the past decade have focused on fertilizer subsidies and targeted credit programmes with hopes that these programmes could later be withdrawn once the profitability of fertilizer use has been made clear to newly adopted farmers and once they have become sufficiently capitalized to be able to afford fertilizer with their own working capital. Relatively little emphasis has been given to improving the profitability of fertilizer use through understanding the most productive levels and combinations of nutrient input for various agro ecological areas, management practices and market options. Inorganic fertilizer does not necessarily improve agricultural productivity in isolation. Information on the fertility status and agricultural potential of the soils are also required. Complementary inputs such as investment in soil and water conservation for efficient nutrient uptake will be necessary for sustainable agricultural productivity growth. Improved soil fertility management through increased levels of fertilizer use, increased use of available organic soil amendments, and improved farm management practices, together with the use of improved seed, is the foundation for a sustainable strategy.

However, at this time there is lack of information on the profitability of the different soil-crop-fertilizer combinations that could be employed in the different parts of the country. The lack of such information on crop-fertilizer profitability across the country means that farmers cannot tell how much they stand to gain or lose by applying a particular type of fertilizer on a particular crop. This increases their risk and creates a disincentive for use of fertilizer. Information about profitability levels can serve as an incentive for inorganic fertilizer use. Most simply, expected Value Cost Ratios (VCR) from fertilizer use can guide farmers' decisions. While detailed information to estimate the profitability of fertilizer use for farmers with different resource constraints and agro-ecologies is largely unavailable, the weight of the evidence indicates that fertilizer use is not clearly profitable for many Ghanaian farmers. Knowledge of soil characteristics and processes regulating nutrient availability and supply to crops is essential to raise productivity per unit of fertilizer nutrient applied.

The recommendation of the African Fertilizer Summit (2006) to increase fertilizer use from 8 to 50 Kg/ha nutrients by 2015 reinforces the importance of fertilizer for increasing crop productivity and attaining food security and rural wellbeing in Ghana. The impact of this target will however vary depending upon the agronomic efficiency of applied fertilizer. This efficiency varies across ecological zones, farms and fields within farms and greatly affects the returns to the recommended 50 Kg/ha. Insufficient and unbalanced fertilization of soils using fertilizers as well as lack of nutrient conservation technology adoption by farmers contribute to accelerating the rapid decline in soil fertility. The efficient uses of both inorganic and organic fertilizers, through Integrated Nutrient Management approach, will form an important element of a holistic approach for sustainably increasing crop production in Ghana.

The sustainability of good crop yields is therefore closely linked with the careful management of the soils with the objective of (i) preventing and controlling erosion, (ii) increasing their organic matter content, and (iii) replacing and increasing plant nutrients lost through erosion and crop uptake.

The study has proposed a number of actions for consideration by the Government of Ghana to address these three classes of problems, as well as the broader market-wide factors constraining farmer investment in sustainable intensification practices. The details of these proposals are contained in Section 4, but the general elements are as follows:

i. **public sector research programs** to identify region-specific best practices for amending soil conditions, given the great micro-variability in agro-ecological conditions in the country;
ii. **public agricultural extension programs** to transfer best practices to farmers as well as provide bi-directional learning between researchers and farmers to refine best practices in light of farmers' experiences in their fields; and,
iii. **input distribution systems** that make available the full range of products and services required by farmers. This is likely to go well beyond inorganic fertilizer and include compost and other forms of organic fertilizer, lime and other factors to address soil acidification based on the use of simple mobile soil testing kits that provide rapid site-specific soil diagnostics to guide fertilizer recommendation decisions by the farmer.
iv. Promoting transparency in the implementation of the FSP, changing the fixed transport cost margins offered to distribution firms, and addressing the widespread issue of seasonal burning of grassland were also noted as important issues to be addressed to promote sustainable agricultural intensification in Ghana.

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APPENDIX: SHORT, MEDIUM AND LONG TERM POLICY OPTIONS

Table 1. Short terms options to improve performance of the FSP (2015-2016)

Challenge	Recommended Action	Responsibility
Uncertainty and unpredictability	2015 tender published already. Disseminate information on subsidy to all stakeholders well in advance of the season.	Minister (MOFA) & Minister (MOF)
Public budgetary cost constraints	Conduct benefit-cost analysis of FSP to guide decisions. Also, encourage private sector to take increased role in the market.	National Input Subsidy Committee (MOFA), Development partners
Blanket fertilizer use irrespective of crop and agro-ecological zone	Begin sensitizing stakeholders on impending changes to FSP (see medium term options for more info).	National Input Subsidy Committee

Table 2. Medium-term Options to Improve FSP (2016-2018)

Challenge	Recommended Action	Responsibility
Blanket fertilizer use irrespective of crop and agro-ecological zone	Employ region-specific data on soils as basis for the type of fertilizer imported Import tender awards to: a) support soil fertility management and b) Ensure fertilizers imports suitable to agro-ecological zones and crops. Or supply fertilizers suitable to ecologies/regions?	National Input Subsidy Committee + Private sector stakeholders
Fertilizer Use Efficiency	• Review best practices that include improved planting material, SOM, water management, • Encourage increased private sector participation to provide credit and support adoption of good agricultural practices	Research Institutes, National Input Subsidy Committee + Extension Service + Private sector stakeholders
Sustainability of FSP	• Endorse the policy of gradual reduction in the subsidy rate along with reforms towards a smarter subsidy • Adopt relevant aspect of the Burundi and Nigeria models	Minister, MOFA
Smuggling of subsidized fertilizer to neighboring countries within ECOWAS	Better tracking using IT to ensure all allocated fertilizer go to intended beneficiaries e.g. the Nigerian GES-TAP system	MOFA (Crops Services) + Development Partners
Delays in payment of importers	• Better tracking using IT to ensure all allocated fertilizer go to intended beneficiaries • Use IT for real time verification , reconciliation and reporting of sales (initiated in 2013) • Timely announcement of FSP well before planting time	MOFA (Crops Services) + Development Partners
Timing and delayed delivery to farmers	• Publish delivery dates and time in advance of the season • Explore innovative financing mechanism for the distributors	MOFA, Private Sector, Banks, Development Partners

Table 3. Long-term Options to Improve FSP (2016-2018)

Challenge	Recommended Action	Responsibility
Sustainability	• Encourage increased participation of private sector in FSP • Government to provide regulatory and quality control oversight • Encourage development of the regional market for produce and inputs	Private Sector, MOFA (Crops Services), Development Partners, ECOWAS