COST-BENEFIT ANALYSIS OF PRIORITISING AGRICULTURE GROWTH IN GHANA

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Prioritising Agriculture Growth in Ghana

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Academic Abstract

This paper had a simple aim. It sought to estimate the magnitude, relative returns, and economic viability of selected interventions in agriculture in Ghana. The five interventions studied were selected because they were implicitly consistent with government's plans to increase agriculture growth and use that as a launching pad for the country's industrialisation plans. The interventions analysed included fertilizer subsidies, increased mechanisation (essentially more use of tractors), improved seeds subsidies, increased irrigation schemes, and more warehouses to help reduce post-harvest losses. The analysis was done for each of the interventions as a stand-alone and there was no attempt to test for complementarities. Since this was a cost-benefit analysis of the different interventions we identified and estimated the cost elements first. Typically, this was made up of some fixed as well as variable costs. The second element, the benefits stream, was essentially the monetised value of incremental output due to the respective interventions – output with intervention less output without intervention. Our results show that all the interventions had a BCR value of greater than 1, implying positive returns to the investments. The most promising interventions were subsidising hybrid seeds and fertilizer. These had higher BCRs of 3.6 and 4.4 respectively at an 8% discount rate. This was followed by mechanisation programme (2.8), OPV seeds (2.3), the warehousing intervention (1.8) and the irrigation intervention (1.5) in that order. We suggest not putting too much weight on the absolute magnitudes due to inherent uncertainties in the analyses, and only some weight on the relative BCRs. That said, it appears that encouraging farmers to use hybrid and fertilizer inputs via subsidies would be more efficient than other interventions. The greatest source of uncertainty, and the one that would change the policy implications the most is the assumed extent and waste associated with smuggling of subsidized seed and fertilizer, particularly the latter. We have attempted to account for these in our analysis using actual expenditure data from government sources. The study concludes by noting that even though these individual interventions do all have positive returns, the very nature of agriculture means that complementarities could result in returns that will be much higher than the sum of the individual returns suggest.

Key Words: Agriculture Interventions, Benefits, Costs, Ghana

Policy Abstract

Intervention I – Subsidising Improved Seeds

Overview

For various reasons, many smallholder farmers in Ghana do not use improved seeds, which are not only more resilient but also provide higher yields. There are four principal factors that contribute to the low uptake of improved seeds. First, knowledge of hybrid varieties among farmers seems to be low. Second, even with knowledge of these varieties, farmers may be too risk averse to try a new technology. Third is the cost, particularly of hybrid varieties. Fourth, is the issue of access. Farmers who may be able to afford are not always able to procure them when they are needed. This is partly due to limited production of certified seeds resulting from a lack of a guaranteed market. Subsidizing improved seeds for smallholder farmers has the potential to address all of these issues either directly (reducing the cost) or indirectly (via decreasing the costs of learning about seeds, improving the demand to stimulate increased production). Increased uptake of improved seeds can increase yields and therefore farmer welfare.

Implementation Considerations

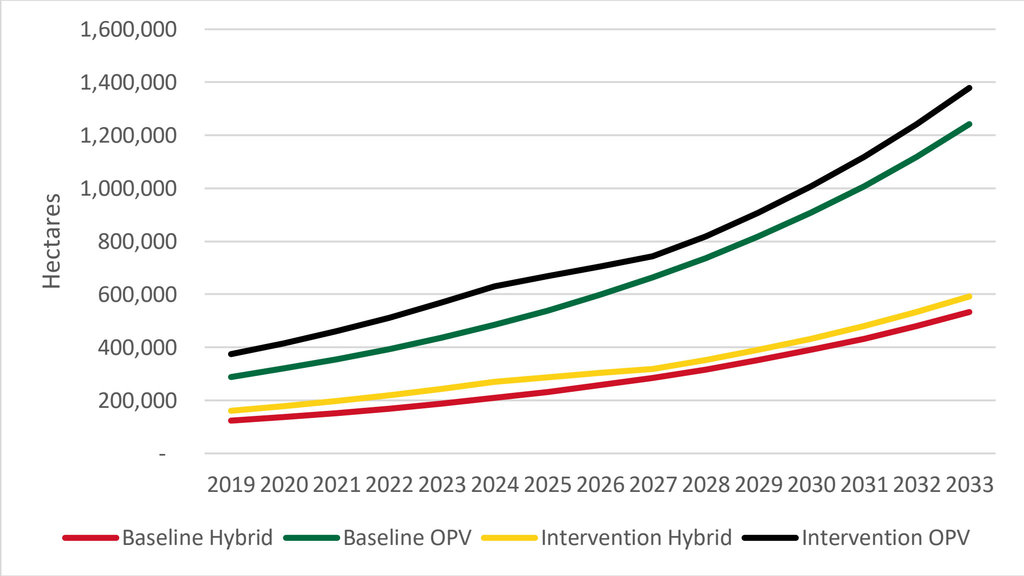
This intervention considers a subsidy on improved maize seeds for both hybrids and OPVs. We focus on maize because it is probably the most popular crop among smallholder farmers and accounts for the highest portion of agricultural land in Ghana. Additionally, improved maize seeds are the most prominent within the seed industry in Ghana. The proposed intervention is for government to continue to provide a subsidy of 50 percent on maize seeds until 2023, reduce the rate to 40 percent in 2024, 30 percent in 2025 and then decrease the rate to zero by 2028. By then, it is hoped, farmers would have observed that the benefits of using certified seeds outweigh the cost and continue using them. The analysis models the impact for a further five years, even when there is no subsidy, to capture these learning gains. The benefits and costs are measured against a scenario where there are no subsidies.

Without persuasion, farmers may not adopt improved seeds for the reasons mentioned above. These risks can be mitigated if government extension agents are a key part of the intervention to demonstrate and ensure farmers appropriately used new seeds and generate the expected yield increases.

Benefit and Cost Estimations

We assume farmers would respond to the lower price of seeds by increasing their use of certified seeds without necessarily increasing total land area of plantations. The estimated use of hybrid and OPV seeds are depicted in Figure 1 for both the intervention and baseline cases. A 50% subsidy boosts the use of seeds by 30%.

Figure 1: Use of improved seed (OPV and Hybrids) - baseline and intervention



The costs of extending the subsidy on improved seeds include the financial outlay of government and the extra costs to farmers, which increase as the subsidy is gradually removed. The public cost of the maize seeds subsidy is based on the budgeted expenditures, as reported by MoFA in the Planting for Food and Jobs documents (MOFA, 2017b), and covers payment for the 50 percent subsidy on the seeds, expenditures for training, publicity, dealing with seeds producers and leakage. Switching from local to improved seeds would also increase fertilizer, labour and transport costs for farmers. The cost of the intervention is GHS 490 million for subsidizing hybrid seeds and GHS 511 million for subsidizing OPV seeds over 15 years. Unsurprisingly, the actual seeds make up most (~80%) of the cost during the subsidy regime. During the five-year period after the subsidy is removed, seeds only make up 50% of the marginal cost.

The primary benefit of the intervention is higher agricultural yields, but this depends on the extent of uptake by smallholder farmers. Based on existing literature, we assume that hybrid seeds increase yield by 2.0 MT / ha, while OPV seeds increase yields by 0.51 MT / ha. The value of increased output averages GHS 156m and 92m per year for hybrid and OPV respectively. An additional benefit is the value of the subsidy for farmers who would have bought seeds without the subsidy. This value averages 36 m for hybrids and 42m for OPV per year.

In total, farmers switching from local seeds to using hybrid seeds generate estimated benefits of GHS 1,750 million as compared to an additional cost of GHS 490 million, assuming an 8 percent discount rate. The BCR is 3.6. If instead OPVs are adopted in place of the local seeds, the estimated benefits would be GHS 1,162 million and the additional cost would be GHS 511 million, resulting in a benefit cost ratio of 2.3. From these results, subsidizing improved seeds would provide net benefits to farmers and to the country.

Intervention II - Fertilizer Subsidies

Overview

The Ministry of Food and Agriculture (MOFA) has reported fertilizer use per hectare among smallholder farmers is between 13kg and 15kg (MoFA 2019). This is far below the optimal level for many crops. The costs associated with fertilizer use have been identified as one of the reasons for its low uptake. Therefore, one way of increasing fertilizer intensity is to reduce the price of fertilizer so farmers can afford the required quantities as reported by Imoru and Ayamga (2015). This intervention examines the viability of a programme that maintains the current 50% subsidy for a period of 5 years with a gradual removal over 5 years back to 26%. An alternative scenario was also built for when the subsidy is completely taken off at 0%. These analyses are compared to a case where subsidies remain at 26%.

Implementation Considerations:

We assume the subsidies will be maintained at 50% over a period of 5 years. From the 6th year, it will be gradually reduced to 45%, then to 40%, 36%, 31% and finally reach 26% by 2028. We analyse benefits for five years after the subsidy is removed / lowered to account for medium impacts of learning.

The main risk with respect to fertilizer subsidies is smuggling. This has and remains a concern of policy and rightly so. The cost to smuggling has also been modelled into the analysis and is estimated at 2.6% of the government’s cost based on government provided data.

Benefits and Costs Estimations

The intervention is expected to boost the use of fertilizer, with the expected change differing by crop. The main assumptions are below:

Crop	Price elasticity to fertilizer use	Elasticity of crop yield to fertilizer use	Elasticity of crop yield to fertilizer price	Actual fertilizer use (kg/ha)	Recommended use (kg/ha)
Yam	-0.83	0.00065	-0.011	10.00	110.00
Maize	-0.83	0.00814	-0.209	40.00	141.30
Cocoa	-0.83	0.00223	-0.816	15.00	187.50
Pineapple	-0.83	0.041	-0.107	15.00	237.50

In general, fertilizer use increases by 27% initially, and decreases as the subsidy is lowered.

The key cost elements of this intervention include the financial outlay of the subsidy, administrative/transportation and leakage (smuggling) costs. There is also the cost to farmers as a result of the use of more fertilizers than they would have otherwise used.

In terms of benefits, it is envisaged that the subsidy will increase fertilizer use by farmers and subsequently improve the yields of crops. Additionally, the reduction in price of fertilizer for the farmers who would have used fertilizer without the subsidy is a benefit.

Over the period 2019 to 2033, the total benefits of the fertilizer subsidy in present value terms is estimated to be GHS 2,011 millions, at a discount rate of 8%. The costs amount to GHS 460 million. We observe that the cash crops, cocoa (BCR = 5) and pineapple (BCR = 20) respond highly to the intervention compared to staple crops (maize; 3.97 and yam; 0.93). The overall BCR is 4.4, and results suggest that at any discount rate, the fertilizer subsidy intervention will engender benefits that will be around 4 times more than the cost. The alternative scenario, reducing subsidy to 0% at the terminal period equally showed positive BCR values indicating the viability of the intervention at all levels.

In all these, private sector players who are the main importers and distributors of the fertilizer stand to benefit from the guaranteed market. However, if inefficiencies resulting from delayed payment by the government persist, it could crowd out their investments.

Since the assumption is that farmers could be weaned off the subsidy subsequently, it is imperative that other accompanying measures come together with the intervention, such as building the capacity of farmers, helping them to better access credit and expanding market access and structures. This will incentivize farmers to increase productivity by adopting best practices including optimal fertilizer application which hitherto has been motivated due to the intervention.

Intervention III - Irrigation

Overview

The effects of climate change continue to aggravate the plight of farmers in Sub-Saharan Africa. The scarcity of water and irregularity of rainfall has been a restraining factor for crop production in Sub-Saharan Africa, and Ghana is not an exception. Public investment in irrigation development in Ghana has declined considerably from the 1990s, and there is increasing uncertainty about the returns to these vast investments (Namara et al., 2011). Previous experience saw public irrigation initiatives stalled due to machinery breakdowns, high electricity costs, old and choked canals and poor service repayments. More recently, there is renewed effort by government to rehabilitate some existing irrigation schemes, leading to some of the abandoned schemes being brought back to production (Akrofi et al., 2019).

This intervention proposes to rehabilitate the following already existing irrigation schemes: Ashaiman, Dawhenya, Weija, Afife, Aveyime, Mankessim, Okyereko, Subinja, Sasta and Akumadan. Even though these are part of the Ministry's long-term plans, they are yet to be implemented. The total area to be covered by these 10 irrigation sites is 3,443 hectares. The rehabilitation of these irrigation schemes covers a period of 30 months as compared to 18 months proposed by the Government for the other schemes. This is to cater for unforeseen challenges that may arise during the implementation phases; including institutional changes that are needed to make the Water Users Association (WUA) effective with governance and the collection of user fees. The performance of smallholder farmers' engagement in irrigation water management in the past has been poor and there have been several instances of default payments (Namara et al., 2011). Hence the intervention includes a mechanism that allows farmers flexible payment so that they are more likely to access the facilities.

Implementation Considerations

For this intervention, ten sites will be rehabilitated over a period of 30 months. The key crops to be grown in these areas include rice, pepper, okra and tomatoes. The intervention assumes that government covers the cost of rehabilitation, while the cost of ongoing maintenance is borne by farmers in the form of user fees. Based on stakeholder interviews, this service fee is about GHS 200 per acre annually (approximately GHS 500 / US$ 91 per hectare).

The schemes will imitate the management structure of existing irrigation schemes being handled by private sector under the regulation of the GIDA. The new operation and management model is envisaged to mitigate the problem of recurrent expenditure incurred by Government, almost every decade, on irrigation management in the country. It will ensure that the only burden on the government will be to repair the main canals every 30 years as there would be enough money generated by the various schemes to maintain the secondary and tertiary canals (Bokpe, 2017).

The institutional changes required to enable this intervention are a source of risk, given known challenges with this type of intervention in developing countries, including Ghana. However, this appears to have been mitigated to some extent with GCAP project – as previously mentioned, a similar initiative to the one described here. According to Koomson (2020), the project which involves the digitization of the Kpong Left Bank Irrigation scheme with an automation system is already about 63% complete.

There are two additional sources of uncertainty that one anticipates with this intervention. The first relates to the pricing of the water which will be done per litre as opposed to what has been done in the past – which was per hectare. A second source of uncertainty is the fact that the scheme will be under private management even though oversight will be by GIDA, as described earlier. Given that farmers are used to the old system, one anticipates some level of apprehension and possible cooperation issues from the farmers initially. This calls for education and sensitization of farmers on the operation of the new system.

Benefits and costs Estimations

The key benefit for this intervention is increased yields. The increase in yield will come from 2 main sources. First the increase due to the more efficient use of nutrients by the plants in the presence of water – here there is increased yield over a production cycle, assumed to be 20%. The second source of the increase is due to the fact that with irrigation, a farmer can have two production cycles in a year. In that case the annualized yield also increases. In this report we assume the annualized yield increases by 100% - i.e. farmers can undertake 2 times production instead of the 1. The benefits are estimated at GHS 514m over a 10 year period.

The implementation of the irrigation rehabilitation programme would have two major cost components. These are rehabilitation costs and maintenance costs. The government would bear the cost of rehabilitation of the irrigation schemes. The cost of rehabilitating an irrigation site is about GHS 104,000 (US$ 20,000) per hectare. Given a size of 3,443 hectares, the the total cost amounts to GHS 360 million (US$69 million), spread over three years.

To ensure longevity and sustainability of the irrigation schemes, the farmers (beneficiaries) would be charged additionally, service fees to maintain the various irrigation schemes. Information was obtained from discussions with a member of the management team of Irrigation Company of Upper Regions (ICOUR) Ghana on the maintenance cost (service and operation charges) of irrigation schemes. Based on that data we note that farmers are charged a service fee of about GHS 200 per acre annually. This amounts to about GHS 500 (US$ 91) per hectare. Maintenance costs after rehabilitation are approximately GHS 2m per year.

By 2030 the total cost of this intervention, discounted at 8% is estimated to be GHS 348 million

Intervention IV – Mechanisation

Overview

Mechanization, particularly access to tractor services, is essential for expanding agriculture as well as improving productivity of the existing farms. Unfortunately, the use of mechanization or tractor services by smallholder farmers remains low in Ghana. Part of the reason is lack of the services in many farming communities. In other places where they exist, costs have been a limiting factor. MoFA estimates that out of the potential merchandisable agricultural land of about eight million hectares, only 2.4 million hectares-representing about 30 percent, are under mechanization. This intervention proposes to increase area under mechanization by 13 percent in the next 10 years through purchasing of additional tractors and implements. Here we expect it to lead to improvements in soil quality (soil moisture, water retention, air circulation, etc.) and thereby result in higher plant growth and development - increased yields.

Implementation Considerations

Our estimation is based on parameters relating to maize. However, we believe this can be extrapolated to other crops such as rice, yams, and cowpea as well. Indeed, other studies based on other crops also show increases in yields as a result of the mechanization (see Osei 2013). We assume that yield will increase by 11% as a result of the mechanization (see Benin et al

2011). Additionally, we assume that more area will be brought under cultivation as a result of the increased use of tractors.

We expect mechanisation to increase by 13% over the next 10 years. This will be over and above what government plans under AMSEC. Our model estimates the costs and benefits stream over the period 2020 to 2039 to ensure all benefits are captured over the useful life of the tractors (the final tractors bought in 2030 will only cease operating in 2039).

One of the key risks has to do with the efficacy of the intervention in delivering the tractors to the right sections of the private sector so as to ensure efficiency of use. Note that one could envisage a situation where the spending on the tractors will be made but there may not be used for their intended purpose, for example due to lack of maintenance.

Benefits and Costs Estimations

The study takes into consideration several cost elements of mechanization. Based on Hossou et. al. (2016) there are many cost components including the purchase of tractor and implements, repairs and maintenance, fuel, insurance and business registration, building of sheds to house the tractors, overheads including depreciation, lubricants, oil, among others.. The total cost of increasing the area under mechanization for this intervention amount to GHS 294 million in present value terms with capital expenditure making up around 4/5th of the cost.

Three main benefit of the intervention is an increase in yield, assumed to be 11% based on available evidence. This leads to an output increase of around 0.2 tonnes per ha. The benefit is estimated at GHS 822 million over the period 2020-2039 (using an 8% discount rate).

The BCR is 2.8.

Intervention V – Building of Warehouses

Overview

A World Bank report disclosed that in Sub-Saharan Africa (SSA), a large amount of food produced (particularly grains), is lost after harvest with an estimated value of US$ 4 billion (World Bank, 2011). For this reason, investing in post-harvest loss reduction is potentially a smart and impactful intervention to ensure food security (GIZ, 2013a). The narrative on post-harvest losses in Ghana is no different. Ansah and Tetteh (2016) recognize the need to reduce post-harvest losses as an essential means of improving food security in the country and one way to minimize post-harvest losses is to manage storage losses. It is expected that when post-harvest storage losses are well managed, farmers will be able to keep their produce for a long time without significant losses, and will be able to sell at good and attractive market prices. Also for subsistence farmers, minimizing post-harvest losses is a way of making sure food is available all year round (Ansah et al., 2018). Hence a reduction in post-harvest losses provides a significant pathway of reducing poverty and improving nutrition.

Because of the risks associated with grain storage, farmers try to minimize losses by selling their grain soon after harvest, leading to low market prices as the markets are flooded with freshly harvested grains (Opit et al. 2014). Conversely during the off-season, the price of maize is usually highest as maize is not easily available. According to Bruce (2016), Ghana loses about 318,514 tonnes of maize annually to post-harvest losses. This figure represents about 18% of the country's annual maize production. Therefore, improving food security particularly for the poor, cannot be accomplished without sufficient maize storage so as to stabilize prices during the off-season. Also, maize could become an economically important export commodity for the country if excess maize produced is stored.

Implementation Considerations

The intervention will look at constructing 46 new warehouses with an average capacity of 1,000 tonnes for the next 3 years. These new warehouses will supplement government's effort in curbing post-harvest storage losses. It must be noted that even with the proposed intervention of additional warehouses, only a small fraction of the post-harvest losses will be addressed. Specifically, the proposed intervention will start with 20 warehouses in 2020. An additional 20 warehouses will be constructed in 2021 and thereafter 6 warehouses will be built in 2023. The capacity of warehouses to be built will be 1,000 tonnes each. It is assumed that postharvest losses which is currently estimated to be about 18% will reduce to about 5% for the maize output that is stored in these warehouses.

Benefits and Costs Estimations

The benefit of this intervention is the value of post-harvest losses avoided. There is an additional benefit in terms of stability and reduction of prices over time (reduction in prices was computed on an annual basis) but this was not estimated in this analysis. In terms of modelling, we essentially capture and value the benefits as a reduction in post-harvest losses associated with the building these 46 warehouses by 2029. As stated earlier, post-harvest losses amount to about 18%. Some studies have found that using scientific methods can reduce grain losses to as low as 2% (Kumar and Kalita, 2017). For our modelling we will assume that the losses will reduce from the 18% to about 5% with the warehouse intervention. This figure makes room for inefficiencies that are still inherent in the storage system. Given that each warehouse can hold 1000 tonnes, the expected post-harvest storage loss avoided is around 6,000 tonnes per year in steady state.

Applying a value per tonne of $370 per tonne, and decreasing 1.2% per year to account for increased supply arising from the intervention, the total benefits for the 15 years of the project life amount to GHS 90 million, using a discount rate of 8%.

The implementation of the intervention will have a number of key cost items. These will include the cost of constructing the warehouses, maintenance cost, handling and administrative cost, warehousing insurance as well as the cost of employing caretakers, aggregators and sub-aggregators. The most important cost assumptions include is the unit cost of a new warehouse estimated at GHS 460,000.00. This estimate was obtained from government's document on Planting for Food and Jobs (MoFA, 2017) and is consistent with that used in Government's budget allocation for the Planting for Food and Jobs Programme (PFJ). By Year 3 when all the 46 warehouses have been built the total cost of the intervention will amount to GHS 6.5 million for that year. For the entire 15 years, which we assume will be the life of the project, the present value of the total costs is obtained as GHS 49 million, using a discount rate of 8%. The BCR is 1.8.

Summary of the BCR for selected Agricultural Interventions in Ghana

Interventions	Benefit (GHS Million)	Cost (GHS Million)	BCR	Quality of Evidence
Improved Seeds Subsidy				
Hybrid Maize	1,750	490	**3.6**	Medium
OPV Maize	1,163	511	**2.3**	Medium
Fertilizer Subsidy	2,011	460	**4.4**	Medium
Revamping Irrigation Schemes	514	348	**1.5**	Medium
Support Increased mechanization	822	294	**2.8**	Medium
Building Warehouses	90	49	**1.8**	Medium

Notes: All figures are for a 8% discount rate

Introduction

Overview

Despite the sector's gradual decline in GDP contribution since the mid-2000s, agriculture remains a very important part of the Ghanaian economy. The sector still contributes about 20% to Ghanaian output. Perhaps more importantly, agriculture remains an important source of employment, with an estimated 44% of all workers engaged in farming in 2013 (Government of Ghana, 2017). Its contribution to total merchandise exports for Ghana in 2018 was 22%, with cocoa contributing approximately 63%. Whilst it is expected that with economic development in the country, resources (including labour) will shift from agriculture to industry and services, this will take some time to materialise given the supply of labour to higher productivity sectors of the economy is inelastic in Ghana (Osei & Jedwab, 2016). Additionally, the government's Coordinated Programme for Economic and Social Development (CPSED) has, as one of its strategic goals the establishment of one factory in every district; the focal point being the transformation of agricultural commodities and hence rural economies (Government of Ghana, 2017). Lastly, agriculture will play an integral part in addressing poverty and food insecurity concerns, particularly if the country is to meet the SDG 1 and 2 targets.

For the above reasons, increasing agricultural output is a policy goal of the Ghanaian government. In the simplest terms, output can increase through one of three mechanisms: increasing area under cultivation, increasing yield, and reducing post-harvest losses. On all accounts there is considerable scope for improvement. Only about 64% of the total agriculture land area of Ghana is cultivated and there is ample potential to expand the area under cultivation. In terms of crops, cultivated maize covers the most land area – about 1.02 million hectares in 2018 (Table 1). This is followed by cassava for which cultivation covered about 0.972 million hectares. Additionally, the yield gaps for these main crops are very large, with realized yields at 50% or less of maximum potential yield (Table 1). Lastly, on losses, data are scarce but all indications suggest post-harvest losses are non-trivial. For example, Bruce (2016) notes that Ghana loses about 318,514 tonnes of maize annually to post-harvest losses, equivalent to about 18% of the country's annual maize production.

Unfortunately, Ghana has underinvested in agriculture. For instance, agricultural expenditure as a share of total public expenditure averaged 3.3 percent from 2001 to 2015 (Benin, 2019; Benin and Tiburcio, 2019). With limited resources, it is imperative that funds are directed to where it may have the biggest impact. Against this backdrop, this report investigates the economic viability of a number of interventions that can help achieve an increase in agriculture output.

Table 1. Area Cultivated and Yields of Selected Agriculture Crops

	Land area under cultivation ('000 ha)					
	2011	2015	2017	2018	%Change (2011-2018)	
Cassava	904	917	926	972	7.5%	
Yam	404	430	493	478	18.3%	
Maize	1023	881	970	1021	-0.2%	
Rice	197	233	239	260	32.0%	
	Yields (Tonnes/ha)					
	2011	2015	2017	2018	% Change	Potential Yield
Cassava	16.3	18.8	20.7	21.3	30.7%	45
Yam	15.5	17	16.7	16.4	5.8%	52
Maize	1.7	1.9	2	2.3	35.3%	5.5
Rice	1.4	1.9	2.1	3	114.3%	6

Source: Data obtained from SGER, 2019

Key Interventions in Agriculture

The interventions that we analyse in this report are based on factors identified as being important in the drive to achieve agricultural transformation and rural development in Ghana. We classify these factors as outlined in the Coordinated Programme for Economic and Social Development for Ghana (CPSED), under two broad areas – *improving production efficiency* and *improving post-harvest management*. We discuss briefly the broad issues from which these interventions are derived.

Improving Production Efficiency – Improved Seed Subsidies

Not enough smallholder farmers in Ghana use improved seeds. For example, the proportion of improved seeds use among yam farmers is as low as 10% (Government of Ghana, 2017). Even though usage rates are higher for cassava, rice and maize (at 35%, 58% and 60% respectively), these levels still remain low given the potential yield dividend from improved seeds. Some of the reasons that have been cited for the low adoption rates include, risk aversion, lack of knowledge, inaccessibility and high cost. The intervention that we model in this report – subsidies for improved seed – addresses some of these constraints by making seeds more affordable to smallholder farmers, as well as reducing the costs of learning about seeds.

Improving Production Efficiency – Fertilizer Subsidies

Inorganic fertilizer use is known to be low in Ghana, worsened by the fact that new crop varieties have higher nutrient requirements. Even when fertilizer is subsidised, smallholder farmers find it expensive. In addition, access and cost of credit makes it difficult for farmers to purchase and use more fertilizers (Government of Ghana, 2017). However, it is also known that fertilizer could lead to a 70% increase in yield. The intervention modelled in this report – extended subsidies for fertilizer – echoes the government's aim to boost the use of fertilizer as part of its overall agenda to improve production efficiency

Improving Production Efficiency – Irrigation Development

Any agricultural system based on rain-fed irrigation is vulnerable, particularly to climate change, and typically results in inconsistent yields. With only about 0.4% of agricultural land under irrigation (Government of Ghana, 2017), maintaining the status quo only makes the poverty reduction agenda more difficult to achieve. So, the intervention here examines the impact on farmers' yields from an expansion of the area under irrigation, with a particular focus on rehabilitating abandoned irrigation projects.

Improving Production Efficiency – Mechanisation

As with many efficiency enhancing inputs, tractor use in Ghana for agriculture remains low. It is for this reason that the government launched the Agricultural Mechanisation Services Centre (AMSEC) programme. The goal of the programme is to improve tractor-farmer ratio for Ghana, which remains much lower than peers such as Nigeria and Kenya (Government of Ghana, 2017). Unfortunately, since its launch in 2007, the tractor services have been characterized by low patronage, owing to the high cost of these services, which in turn is driven by the high maintenance costs of the tractors. We assess an intervention that provides mechanization services for smallholder farmers over a period of ten years.

Post-Harvest Management – Building Warehouses

Post-harvest losses are significant and occur at various points along the agriculture value chain. Reducing these losses forms part of the broad agenda to transform agriculture in Ghana. The government therefore plans to facilitate the provision of storage infrastructure and establish a warehouse receipt system. We therefore provide an analysis of providing these warehouses and thereby reducing the losses that farmers make, post-harvest.

Intervention I - Subsidising Improved Seeds

Description of the Intervention

The Problem

The use of improved seeds by smallholder farmers is crucial for improving yields and output. However, for various reasons, smallholder farmers in Africa and other poorer regions are less likely to use them for planting (USAID, 2017). The cost of the seeds to smallholder farmers, especially the hybrid varieties, is probably a principal factor for their low uptake (van Loon et al. 2019). Availability of the seeds to the farmers is also a problem even for those who may be able to afford them. For this and other reasons, the government of Ghana decided to subsidize the improved seeds on the market as part of the Planting for Food and Jobs policy (ISSER 2019). The majority of farms in Ghana are below two hectares in size, and are farmed by households who have relatively low welfare outcomes as compared to other occupations. Subsidizing such farmers has the potential to improve the welfare of these smallholder farmers and consequently improve income distribution in the country.

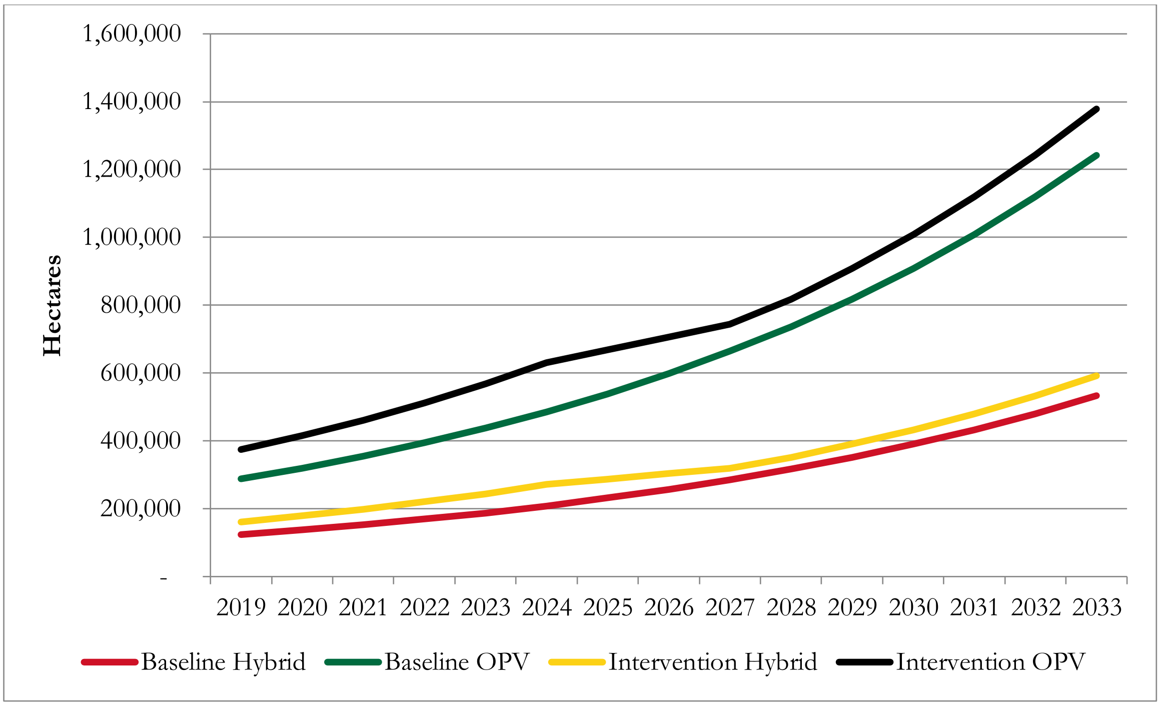
The analysis that is done in relation to subsidizing improved seeds is based on maize. This is because maize is probably the most popular crop among smallholder farmers and considered almost a cash crop (Tripp and Mensah-Bonsu, 2013). As also highlighted earlier, it accounts for the highest portion of agricultural land use in Ghana, and it is planted for both household consumption and sales. Added to this is the fact that improved maize seeds are most prominent in the seeds industry in Ghana. One Open Pollinated Variety (OPV) called *Obatanpa* dominates the market, even though it has been shown that hybrid varieties have higher yields on average than the *Obatanpa* (Tripp and Mensah-Bonsu, 2013). Unfortunately, knowledge and use of the hybrid varieties among farmers seem to be low (USAID, 2017). Ragasa et al. (2013) reported that only about three percent of maize farms were planted with hybrids. Only a small percentage of all farmers are already using improved seeds (OPVs and hybrids). It has been observed that below six percent of farmers use certified seeds even though this percentage may be a little higher for maize (USAID, 2017). Of the lower than desired certified maize seeds being sold, the report for "Feed The Future Ghana Agriculture Policy Support Project showed that more than 80 percent of the seeds on the market "are Obatanpa, and less than 8% are hybrids" (USAID, 2017, p77). Adu-Gyamfi, Birner and Gupta (2018) report that about 18 other improved seed varieties have been released after *Obatanpa*, but just a few are produced for farmers. An intervention by the government to make these hybrids more accessible to farmers is worth investigating.

The proposed intervention is for government to provide a subsidy of 50 percent on maize seeds for five years and gradually remove the subsidy until there is no subsidy by the tenth year. It is expected that after the subsidy period, farmers would have experienced the benefits of the improved seeds and made savings to be able to purchase the seeds on their own when the subsidies are gradually removed. Indeed the policy documents includes plans to "carry out a gradual reduction in the subsidy rates" (MoFA 2017, p22). It is therefore premised on a change in behaviour of the smallholder farmers in favour of using improved seeds once they recognise and internalise the advantages of the improved seeds over local seeds. This intervention is assessed against a baseline of zero subsidization of improved seeds. The analysis is done separately for hybrids and OPVs. It is assumed that the business of private agro-inputs dealer would not be adversely affected by the subsidy. The policy is to be implemented in conjunction with private seed developers and would therefore give a boost to their production instead of hamper it. The government does not produce the seeds but subsidizes what has been produced by the private sector.

Both the intervention and baseline scenarios require assumptions about the uptake of improved seeds. For the the elasticity of the use of improved seeds to price during the subsidy regime was estimated at -0.6 using data from Wave 2 of the Ghana Socioeconomic Panel Survey. Also 20% increase in usage of improved seeds is assumed when the subsidy is gradually removed to account for learning. In the baseline, annual growth of improved seeds used is estimated as 11 percent using data from-2002 to 2013 during which there was minimal subsidization of seeds (Tripp and Ragasa, 2015). Additionally, we assume a seeding rate recommended by MoFA in the PFJ document of 22.5kg/ha for hybrids and 25kg/ha for OPVs. Lastly, it is expected that farmers would not necessarily increase acreage but replace local seeds with improved seeds. The subsidy is intended to increase the proportion of farmers using certified seeds or the proportion of farms planted with certified seeds. A significant expansion of maize farms in Ghana as a result of the subsidy is not expected but rather farmers will replace local for improved seeds.

Based on these assumptions, the expected pathways in terms of hectares of improved seed are provided in Figure 2. In year 1, the increased demand for improved seeds will result in an increase in land area by 123,556 hectares for which these additional improved seeds will be used on – of this 30% will be hybrid and 70% OPV. This means that in total the land area under for which the improved seeds will be grown in Ghana will be 535,407 hectares in Year 1. By the end of the subsidy regime (2028) we expect there to be no subsidies on either seed, but due to learning, improved seed usage is higher under the intervention scenarios. We project out for a further five years to capture this added benefit assuming the 11% growth rate remains.

Figure 2: Area under improved seed (OPV and Hybrids) - baseline and intervention



Valuation of Benefits and Costs

The valuation of benefits and costs were based on simple assumptions as to what would change when farmers switch from local seeds to the improved seeds (hybrids or OPVs). The computations are based on the increased planting area for improved seeds as farmers respond to the price reducing effect of the subsidy.

Benefits of subsidizing improved maize seeds

A subsidy on improved seeds is expected to lead to an increase in its usage, and consequently maize yields. To avoid confounding effects of fertilizer use on yield, the yield per hectare adopted here assumes the current fertilizer application rate for maize remains same.[1] The

[1] Fertilizer usage on the improved seeds is assumed to be 20 kg/ha, with a 1 percent growth in fertilizer prices per year. The cost of fertilizer (unsubsidized) is GHS 2.76 (US$ 0.53) per kg.

impact of improved seeds on yield is based on data from USAID (2017). The baseline yield is assumed to be 1.99MT/ha and after the subsidized adoption, the yields are 4MT/ha for hybrids and 2.5MT/ha for OPVs assuming farmers use the prevailing fertilizer application rate.

The change in planting area is multiplied by the difference between yields associated with use of local seeds as against that with the improved seeds (e.g for hybrids: 4 less 1.99 tons per hectare). The resulting figure represents the gain in output per hectare from inducing farmers to switch to certified seeds. In the first year the *increase* in output is 61,458 MT for hybrid seeds and 36,369 MT for OPV seeds. By the end of the period of analysis, the corresponding figures are 97,277 MT and 57,481 MT respectively.

This stream of output improvements is then multiplied by the price of maize which is taken as GHS 1,924 (US$370) per tonne[2] (converted to GHS using an exchange rate of 5.52 for base year and depreciated by 2% annually for the respective years that follow), to get the total value of revenue benefits for each year. An additional benefit is the value of subsidy transfer for those who would have bought seeds without the intervention. This is calculated by taking the value of improved seed planted in the baseline scenario and multiplying by the subsidy per seed, if any. Over the 15 year-period the present value of these benefits, discounted at 8 percent, amount to GHS2,913 million – with GHS 1,750 million due hybrids and GHS 1163 million due OPVs (Table 2).

Cost of subsidizing improved maize seeds

The costs of implementing the subsidy on improved seeds include the financial outlay of government and the extra costs to farmers for switching from local seeds to improved seeds. The price of certified maize seeds paid by farmers GHS 14.51 (2.79US$) for hybrids and GHS 2.76 (US$1.53) for OPVs is based on USAID (2017, Table 1, p30). Note the costs account for the fact that the intervention requires subsidising all seed, even those that would have been used without the intervention.

The cost of maize seeds to the farmer is estimated by multiplying the price of the seeds on the market by the subsidy rate, but the cost of grain seeds is subtracted and the resulting figure multiplied by the recommended seeding rate for a hectare. It is assumed that the local seeds

[2] The average price of grain maize in Ghana was estimated from actual payments in the GLSS7 data (which is a nationally representative data set collected by the Ghana Statistical Service). This was used as the price of local maize saved and not planted and also acts as a check on the prices of seeds used.

that would have been planted without the improved seeds could be sold at the price of grain maize to defray part of the cost of acquiring the improved seeds. The average price of grain maize in Ghana was estimated from actual purchases in the GLSS7 data. Further costs are added to take care of extra transport (an average of GHS 17 per hectare) and labour (an extra day at GHS 17 per hectare) as a result of switching to improved seeds. Since the yields assumed in the computations of the benefits involve the use of fertilizers, a cost of fertilizer is included for marginal hectares of improved seed. This is based on the current fertilizer application rate and the price per kg of fertilizers assuming no subsidies on fertilizers.

The public cost of the maize seeds subsidy is based on the percentage of the cost of seeds to be paid by the government, multiplied by the seeding rate per hectare for each seed type. An administrative and leakage cost of the subsidy is assumed, additionally, at 14 percent of the public cost of the subsidy. This is to cover all cost specified in the PFJ document (MoFA 2017, page 66) such as training, publicity, dealing with seeds producers and other perceived adverse productivity effects associated with rent-seeking that results from subsidies. Since farmers will pay for the seeds at designated banks (or done via mobile money), and present receipts to specific input dealers, potential abuse of the system can be detected and investigated. Thus, adverse effects of rent-seeking behaviour are not expected to be high.

So for instance in Year 1, the total costs of the imporved seeds subsidy which will cover the additional hectares will be about GHS 100 million – with about GHS 55 million for OPVs and about GHS 45 million for the hybrid. Across the years, seeds make up the majority of cost during the subsidiy period, where they are 60-80% of the cost. However, in the post-subsidy period, seeds only make up slightly less than 50% of the cost, with the other cost components comprising the remainder.

Over the 15-year period, the total costs for this improved seeds subsidy intervention, at a discount rate of 8% will be GHS 1000 million.

Discussion of the BCR

The present value of the total benefits and costs have been reported in Table 2. The Benefit-Cost Ratios (BCR) reported in the table are 3.6 for hybrids and 2.3 for OPVs, resulting in an overall average of 2.9 using a discount rate of 8 percent. This means hybrids return more benefits per cedi spent as compared to OPVs. This may explain why it was recommended in USAID (2017, p81), that the “PFJ should only include hybrids for maize to increase yields”.

However Adu-Gyamfi, Birner and Gupta (2018) report a replanting advantage of the OPV called Obatanpa which makes it preferable by farmers over the hybrid, which typically exhibit recessive traits. However even with OPVs, saving seeds for replanting typically reduces efficacy of the seeds and is discouraged. It is hoped that subsidising the seeds would reduce the probability of replanting[3].

Table 2. BCR of Improved Seed subsidy intervention.

	Hybrid Maize (GH million)			**OPV Maize (GH million)**			**Overall (GH million)**		
Discount Rate	PV Benefits	PV Cost	BCR	PV Benefits	PV Cost	BCR	PV Benefits	PV Cost	BCR
5%	2127	587	3.6	1403	603	2.3	3530	1190	3.0
8%	1750	490	3.6	1163	511	2.3	2913	1001	2.9
14%	1248	358	3.5	840	382	2.2	2088	740	2.8

Source: Authors Computation

Providing improved seeds subsidy is shown to be beneficial. For maize we note that the benefits outweigh the costs by almost three fold. That is, a cedi spent on the subsidy for improved seeds will yield a return which will be almost three cedis worth of extra output. The source of the benefit is largely due to the yield gains from improved seeds adopted following the subsidy.

There are other benefits of the program that are difficult to measure. For instance with improved seeds, the quality of maize grains is on average better than the local varieties. One could also think of the potential for generating a net export for maize grains. This would have favourable implications for the local currency and would also have other balance of payments benefit. The increased production of maize output will also have positive effects for the poultry and livestock sector since a significant percentage of maize grains are consumed in the poultry industry (Tripp and Mensah-Bonsu, 2013).

There could be downside risks associated with the subsidy programme, which will include logistics and the non-availability of the improved seeds on a sustainable basis for farmers. The timing of the seeds is also critical. If farmers do not obtain the seeds at the right time, yields would be affected because of the rain-fed nature of their farming. This could also push some

[3] Yields drop when OPVs are replanted but literature on the extent of the drop is scanty. It is not clear what percentage of farmers would replant and what percentage would always buy new seeds each season. The non-availability of these key parameters make factoring replanting in the analysis difficult and therefore left unaccounted for. The goal is that farmers should not replant.

farmers to return to replanting saved maize seeds instead of using the certified ones. Subsidies are also known to encourage corruption and rent seeking behaviour.

Implications for Policy

The main recommendation for this intervention is that the government should consider subsidizing improved seed given the size of benefits relative to costs. Even though the analysis is done for maize, it is believed that the positive returns to the subsidization of improved seeds could also be relevant for other crops under the Planting for Food and Jobs policy. Planting the right varieties of rice, for instance, could have huge benefits because of the amount of forex used to import rice into the Ghanaian market each year.

Left on their own, farmers who are typically risk averse may not adopt improved seeds. This is because the price of the improved seeds and the uncertainty associated with using less familiar inputs makes the cost to the farmer very high. Of course, the subsidies will not necessarily reduce the uncertainty. What it does however is to reduce the perceived cost of failure to the farmer, and thereby encourage the uptake of certified improved seeds.

Government extension agents can play a huge role in raising awareness among farmers regarding the use of improved seed varieties. They also must play the role of monitoring and reporting bumper harvests so that corrective measures can be taken to mitigate post-harvest losses, as these tend to discourage farmers from such investments. Complementary inputs like irrigation, the availability of farm labourers and market outlets for the expected increase in maize outputs should be put in place before the end of the subsidy period. Extension agents should discourage the farmers from replanting their harvested maize. This information could also be stressed on in radio and television programs in the farming districts. Implementers of the program should ensure that each year's quota of seeds reach the market at the right time and suppliers are paid promptly to ensure sustainability of the supply of the improved seeds.

Intervention II - Fertilizer Subsidies

Description of intervention

The Problem

Low agricultural productivity derived from sub-optimal fertilizer use, has been an issue for successive governments and various stakeholders. The Ministry of Food and Agriculture (MoFA) has reported fertilizer use per hectare among smallholder farmers to be between 13kg and 15kg, which is far below the optimal for many crops (MoFA 2019). This has also been highlighted in Carter, Laajaj, and Yang (2014) where fertilizer use in the sub Saharan Africa region was reported to be about 13kg/ha. It has been noted that the costs associated with fertilizer use is one of the reasons for its low uptake (Government of Ghana, 2017). Therefore, one way of increasing fertilizer intensity is to reduce the price of fertilizer so farmers can afford the required quantities (Imoru & Ayamga, 2015). A fertilizer subsidy programme is one key intervention that governments may pursue to bridge this gap.

Though faced with many challenges, the Government of Ghana has pursued fertilizer subsidy programmes since 2008 (MoFA 2017a). The latest iteration of the fertilizer subsidy was instituted in 2017, with a 50% subsidy above the earlier rate of 26% (MoFA 2017a). By 2018, 880,000 farmers had been counted as beneficiaries. The Ministry of Finance (MoF) reported a total coverage of 920,000 farmers with the subsidy programme in 2019 (MoF, 2019).

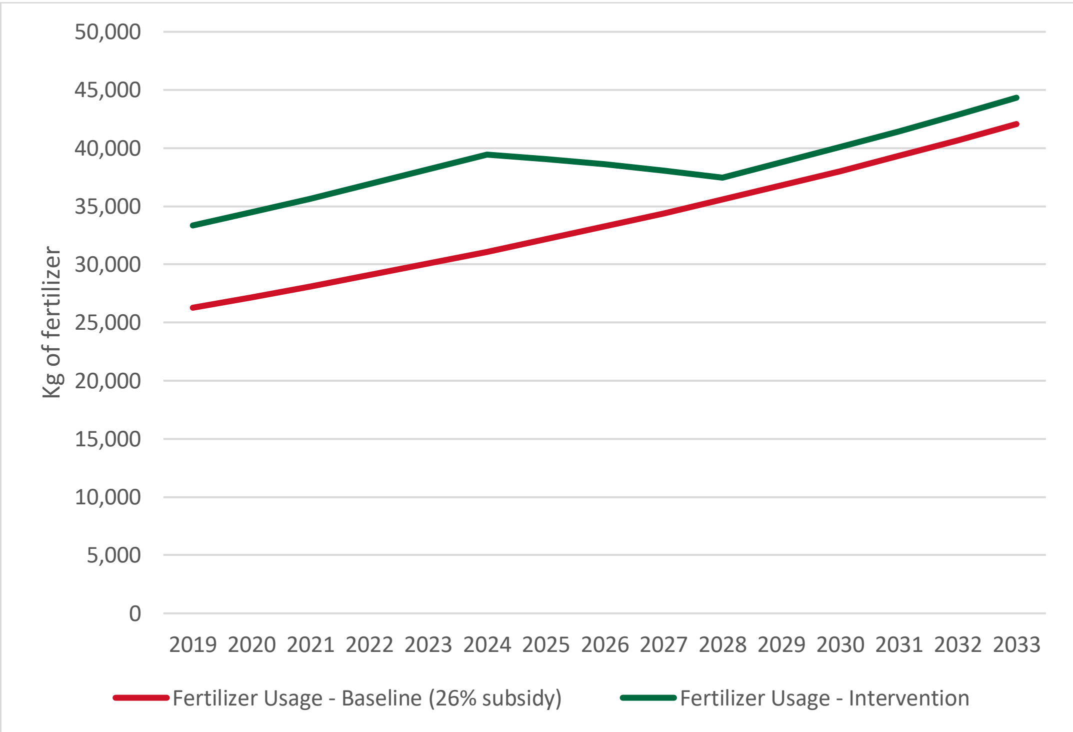
The intervention that is analyzed in this report explores the viability of the subsidy on fertilizer being increased to 50% over the next 5-year period and then decline over the next 5 years back to the baseline level of 26%. We also explore the scenario where the subsidies are reduced to zero in sensitivity. Intervention scenarios are assessed against a baseline of 26% subsidy rate across the years. While this is not the current subsidy rate, it has been the prevailing rate for some time, and there is available data to measure the baseline.

The elasticity of fertilizer use to price during the subsidy regimes is estimated at -0.83. This was estimated based on the current and projected price of the fertilizer vis-à-vis the level of fertiliser use in Ghana. The period over which the elasticity was calculated was between 2009 and 2017 per the available data. The ratio of the year-to-year change of the fertilizer quantity used for agricultural activities and the year-to-year change on the price of fertilizer was used in estimating the average elasticity of -0.83; We assume a sustained fertilizer usage effect of about 20%. This means that once farmers increase fertilizer use with the subsidy, the effect of removing the subsidy will not be symmetric. The implication is that once we start reducing the subsidy from the intervention levels, the response of farmers will be less elastic compared to when the subsidy was introduced. The usage of fertilizer in the absence of the intervention is assumed to grow at 3.4% per year according to data from FAOSTAT.

There are two underlying factors related to fertilizer subsidy programmes that drive our analysis. The first is that the subsidies make the fertilizer cheaper and hence farmers use more of it to increase their yields. A second related reason is that the implicit 'demonstration effects' (from getting higher yields from increased fertilizer use) coupled with the increased farm incomes engenders a sustained positive change in fertilizer use by farmers. This means that the subsidy effects persists beyond the subsidy period so that a decreasing subsidy (and therefore higher price of fertilizer) will have a lower elasticity than it would have otherwise had. As with seeds subsidy, we model effects for 15 years to capture medium term effects.

The analysis is carried out based on selected major food and cash crops grown in Ghana, namely yam, maize, cocoa and pineapples. Two are major food crops and the other two are major cash/export crops. An example of the stream of fertilizer usage for cocoa is presented in Figure 3. Similar shaped profiles are generated for the other crops.

Figure 3:Kilograms of fertilizer used on cocoa (Baseline and intervention)



Main assumptions

The assumptions underlying the estimation of the benefits and costs of the fertilizer subsidy intervention include the following:

- The unsubsidized cost of fertilizer is estimated at GHS 2.76 (US$ 0.53) per kg in 2018 prices.
- The growth rate in yield of 1% is used to estimate the projected yields over the 5-year period in the absence of the intervention and serve as the counterfactual;

- Land area under cultivation used in the computations were sourced from FAOSTAT. For 2017, area harvested included, 1,690,237ha for cocoa; 1,000,000ha for maize; 1,0734ha for pineapple and; 465,906ha for yam;

- Existing fertilizer use pre-intervention is assumed to be 19.0, 19,0, 25.4 and 63.5kg per ha for cocoa, yam, maize and pineapple respectively.

- The output prices of cocoa, yam, maize and pineapple are GHS 9,427.6 GHS 2,735.2 GHS 1,924 and GHS 1,752.4 (US$ 1,813, US$ 526, US$ 370 and US$ 337) respectively in the first year and this is projected into the future using historical annual price changes. The respective yields of these crops is assumed to be 0.5, 17.4, 2.0, and 61.8 tonnes per ha in the first year.

The benefits and costs are estimated using elasticities of fertilizer use to price and the elasticity of yield to fertilizer use. Actual and recommended fertiliser use was also used in the estimations as indicated in Table 3.

Table 3 Elasticities and fertilizer use-values used in the BCR estimation

Crop	Price elasticity to fertilizer use	Elasticity of crop yield to fertilizer use	Elasticity of crop yield to fertilizer price	Actual fertilizer use (kg/ha)	Recommended use (kg/ha)
Yam	-0.83	0.00065	-0.011	10.00	110.00
Maize	-0.83	0.00814	-0.209	40.00	141.30
Cocoa	-0.83	0.00223	-0.816	15.00	187.50
Pineapple	-0.83	0.041	-0.107	15.00	237.50

Source: Authors' computation (2020); MoFA (2017b); Fawole and Ozkan (2018); FAO (2005)

Values for actual fertilizer consumption per crop was not readily available for all crops but the Ghana socioeconomic panel data provided us with estimates for cocoa and maize. Values for pineapple and yam were based on literature (Akhilomen, Bivan, Rahman, & Sanni, 2015; Asieku, Otoo, & Asare, 2015; Enesi, Hauser, Lopez-Montez, & Osonubi, 2018). Cocoa yield response to agrochemical inputs from past studies (Fawole & Ozkan, 2018; Onumah, Onumah, Al-Hassan, & Brummer, 2013) was used to proxy the fertilizer response to cocoa since data on elasticity of yield to fertilizer was difficult to come by.

Valuation of Benefits and Costs of Fertilizer Subsidy Intervention

Benefits of Fertilizer Intervention

It is envisaged that the subsidy will increase fertilizer use by farmers and subsequently improve the yields of crops (Druilhe, 2017; Jayne, Mason, Burke, & Ariga, 2018). The benefits will come in the form of increased yields. As with the seeds intervention, benefits are twofold: production value change and subsidy value change to the farmer.

Maize farmers currently using fertilizer for instance, will be expected to use more fertilizer due to its cheaper price resulting from the subsidy. For maize this price decrease will result in a 66.2kg/ha increase in fertilizer use from the pre intervention quantity of 40kg/ha. Based on a yield increase of 0.01 tonnes per hectare, GHS 1,898 (US$ 365) price per tonne and 868,000 ha under cultivation, we estimate a benefit of GHS 90 million for first year and this increases to about GHS 106 million in the 5th year. However, after the 6th year, at which time the 50% subsidy has been reduced, a reduction in the value of the benefits begins. The other crops under consideration showed similar benefit trend for the period of the intervention.

In terms of subsidy benefits: the pre-intervention fertilizer cost was GHS 2.08 (US$ 0.4) per kg and post-intervention is GHS1.40 (US$ 0.27) per kg. It is assumed farmers would continue to use 22 million kilograms of fertilizer for maize crops in the absence of the intervention. Thus the subsidy benefit is the price differential GHS 0.68 (US$ 0.13) / kg multiplied by 22 million kiligrams for a benefit of GHS 11.4 million (US$ 2.2 million) for the first year.

This procedure was replicated for all other years, and the other three commodities analysed for this intervention. The discounted total benefits at 8%, amounted to about GHS 2011 million resulting from the subsidy over 15 years (Table 4).

Costs of Fertilizer Intervention

The costs of the intervention include the financial outlay of the subsidy by government and the price differential paid by farmers.

It has been pointed out that there can be substantial costs associated with fertilizer subsidies generally, which will be over and above the cost of administering it and so this has to be taken into account when implementing such interventions. Indeed, as noted in Jayne and Rashid (2013), the cost of subsidy programmes could outweigh the benefits, and the Government of Ghana has experienced substantial losses associated with mistargeting and distribution leakages. Indeed, a recent fertilizer optimization study conducted by the International Fertilizer

Development Centre (IFDC) have also highlighted the challenges bedevilling the subsidy programme. That report suggested that some of the major setbacks of the 2015-2018 fertilizer subsidy programme included delayed payment and supplies to farmers, poor voucher accounting, smuggling, low productivity, among others (IFDC, 2019). We therefore factor such leakages into the analysis to fully understand the cost and benefits of the intervention.

The percentage of cost accrued from smuggling is assumed to be 2.6% of the total subsidy cost. As indicated by Cameron, Derlagen, and Pauw (2019), offering fertilizer subsidies is also an avenue to encourage smuggling due to the lowered prices of fertilizers. It is therefore important to build in the cost of smuggling into such an analysis. We use the Government of Ghana's estimated loss of GHS 62.4 million (US$ 12 million) to smuggling in the 2018 fiscal year (GBN, 2019; IFDC, 2019). The total cost of subsidy budgeted for by the government between 2017 and 2020 was estimated at GHS 2,366 million (US$ 455 million) (MoFA 2017a). Hence the GHS 62.4 million (US$ 12M) represents a 2.6% of the total cost of the subsidy. To corroborate this assumption, it was also mentioned during a validation workshop with MoFA that the cost to smuggling is about 2-5% of the total cost of the subsidy.

The costs are estimated in three streams as follows;

- Cost change due to government subsidy increasing from 26% to 50% and then decreasing to 26%. Note that the relevant counterfactual is a 26% price subsidy and costs are measured relative to this benchmark.
- Cost change due to administration of subsidies (5% of subsidy value) as well as leakages which will result from the smuggling (2.6% of subsidized value); and
- Cost to farmers due to the increased cost of production that will come from using more fertiliser.

Note that essentially the above calculations generate a cost that is the sum of the complete cost of the new fertilizer used, the additional subsidy increment on existing fertilizer used plus administration and smuggling costs.

Based on these assumption we estimate the total cost to be incurred by the subsidy programme at 8% discount rate, to amount to GHS 460 million for the four commodities under analysis. The estimated cost as observed is lower than the benefits which implies the benefits of the programme outweighs the cost. Benefit Cost Ratio (BCR) of the various crops analysed under the intervention is discussed in the following section.

Discussion of the BCR

In computing the BCR, all costs and benefits were discounted at 5%, 8% and 14% rates to account for future values. The results show that the food crops had smaller BCR values compared to the cash crops as seen in Table 3. Crops categorised as cash crops in Ghana's agriculture are mostly industrial and export driven and hence potentially receive higher returns on investment, all other things being equal. The returns are mainly from the export value received on these crops as compared to most food crops that are traded on the local market. This could explain why cocoa and pineapple observed a comparatively higher response to the fertilizer subsidy intervention.

One can also observe that the BCR for pineapple is much higher than the other crops, even compared to the other cash crop, cocoa. This mostly driven by the large assumed response of pineapple yield to fertilizer use compared to the other crops. The elasticity of pineapple used in our estimation was obtained from two studies (Akhilomen, Bivan, Rahman, & Sanni, 2015; Ninson 2012) only one of which was from Ghana.

However, what we also noted a drastic reduction of the BCR when the elasticity was changed to levels comparable to those of the other crops. This suggests that the response of crop yields to fertilizer use is one key parameter that has to be verified prior to large-scale implementation.

An opposite elasticity effect can also be seen with the yam where BCR is low. Crop targeting should be considered as not all crops may respond well to the intervention. It is therefore not surprising that the current fertilizer subsidy programme by the government targets grains such as maize, in addition to cocoa under the Ghana Cocoa Board.

That notwithstanding, it can be concluded that increasing the fertilizer subsidy to 50% and gradually phasing it out remains a viable intervention as the benefits outweigh the costs involved (except for yam). The overall BCR suggests that at discount rates of 5% to 14%, the fertilizer subsidy intervention will yield 4 times benefits over cost and hence should be pursued. The crops selected are highly valuable in terms of income and food security and hence these BCR values suggest that the intervention has merit.

Table 4 - BCRs for Fertilizer subsidy (Scenario 1 – Subsidy returns to current level of 26%).

BCR	**Cocoa**	**Yam**	**Maize**	**Pineapple**	**All**
5%	5.21	0.93	4.02	20.26	4.42
8%	5.15	0.93	3.97	19.69	4.37
14%	5.06	0.92	3.91	18.82	4.29
Total benefits, GHS (million)					
5%	1,426	62	724	115	2,328
8%	1,233	54	626	98	2,011
14%	954	42	485	74	1,555
Total costs, GHS (million)					
5%	274	67	180	6	526
8%	239	58	158	5	460
14%	189	46	124	4	363

Source: Authors computations (2020)

Sensitivity Analysis

When the model was simulated to have the subsidy completely taken off instead of coming down to the pre-intervention level of 26%, the BCRs consistently showed positive values, even though they reduce compared to the base scenario. In large part this reduction in the BCR is a result of a reduction in the benefits stream. We do note from Table 5 for instance, that at discount rate of 5% the benefits stream is negative GHS 17 million for pineapple. In general the benefits reduce by a significantly larger proportion than the costs resulting in a reduction in the BCRs.

Table 5 BCRs for Fertilizer subsidy (Scenario 2 – Subsidy goes to Zero)

BCR	**Cocoa**	**Yam**	**Maize**	**Pineapple**	**All**
5%	2.36	0.71	1.94	-11.07	1.86
8%	3.51	0.80	2.77	1.14	2.89
14%	4.33	0.86	3.37	10.05	3.62
Total benefits, (GHS million)					
5%	175.71	13	95	-17	266
8%	318.21	18	166	2	504
14%	445.17	21	228	21	716
Total costs, (GHS million)					
5%	74.32	18	49	2	143
8%	90.74	22	60	2	174
14%	102.82	25	68	2	198

Source: Authors computations (2020)

Recent discussions additionally suggest that the efficacy of fertilizer can be enhanced by adhering to site specific fertilizer applications. It is argued that blanket fertiliser application has been one of the main reasons for the low productivity gains in Africa's agriculture (Dossa et al., 2018). The BCR estimations have been done on the assumption of blanket fertilizer application approach. This means that the benefits could even be further enhanced if a site-specific approach is adopted. This would require investment in soil testing to ensure fertilizer applications are site specific and meet the right nutrient requirement of the agricultural lands. We do not model site specific use of fertilizer as and leave it as an avenue of further investigation. However, we believe it will add favourably to the BCR should it be done.

The private sector plays a big role in the fertilizer market in Ghana as they remain the main importers and distributors, positioning them to be key partners of the programme. With the implementation of the fertilizer subsidy programme, there are both win and lose scenarios for the private sector. The positive is that they have guaranteed market for their products knowing the government will automatically buy from them for the beneficiary farmers. Demand for fertilizer would naturally go up given that farmers who hitherto were unable to afford fertilizer will now be able to, and that will be good for the private sector. However, the alternative scenario is where their markets are potentially contracted because government subsidised fertilizer will be on the market at a much lower price, crowding out the private importer. This could inherently favour farmers who would have otherwise afforded fertilizers at the normal market, subsequently making such farmers "richer" as indicated in Wanzala-Mlobela, et. al. (2013). Some have even argued for the targeting of the subsidy where the poor are given access and those who can afford at the normal market price are exempted (Houssou, et. al. , 2017). The challenge with such an option is identifying which farmers are poor since majority of farmers in this part of the world are poor smallholders.

In Ghana, there have been concerns regarding delays in government payments to the private sector enterprises involved in the subsidy programmes, and with adverse consequence for private sector growth (Goyal & Nash, 2017; Wanzala-Mlobela et al., 2013). However the nature of the fertilizer sector is such that, these enterprises will still remain in business with or without the fertilizer subsidy intervention. The likes of Wienco and Yara Ghana have been in operation over the years, regardless of the type of fertilizer policy in place. That notwithstanding it is important that public policy appreciates this problem and put in place appropriate measures to mitigate some of these setbacks to critical private sector actors in the agricultural input value chain.

Implications for Policy

Given the general viability of the fertilizer subsidy intervention, government is encouraged to implement it, though consider targeting specific crops that might generate larger returns. Since the assumption is that farmers will be weaned off the subsidy eventually, it is imperative that other accompanying measures come together with the policy, such as building the capacity of farmers, helping them to better access credit and expanding market access and structures. This will incentivise farmers to increase productivity by adopting best practices such as optimal fertilizer application which hitherto has been motivated through the intervention.

The government of Ghana has acknowledged the leakages in the fertilizer subsidy programme resulting from smuggling and distribution inefficiencies, with the government estimating that it loses about US$ 2 million to smuggling of fertilizers under the subsidy programme. Efforts are being made to employ digitized systems, combined with the assignment of monitoring officers to each of the distribution points to control smuggling and other leakage sources. If such measures are implemented effectively, government may save this amount whilst also improving fertilizer access to and use by farmers. Finally, to ensure a win-win for the private sector, it will be imperative to reduce the inefficiency associated with the programme, particularly those related to delays in payment by the government. The argument of targeting poor farmers has also come up in the discouse although this might be quite expensive for a policy that will in effect sieve out very few smallholder farmers. As has been argued by many, poverty in Ghana has an agricultural face.

Intervention III - Irrigation

Description of the Intervention

The problem

The effects of climate change continue to aggravate the plight of farmers in Sub-Saharan Africa. These farmers, who are largely smallholders, are already vulnerable to declining crop yields (Adhikari et al., 2015). The scarcity of water and irregularity of rainfall has been a restraining factor for crop production in Sub-Saharan Africa, and Ghana is not an exception.

Public investment in irrigation development in Ghana has declined considerably from the 1990s, and there is increasing uncertainty about the returns to these vast investments (Namara et al., 2011). Previous experiences saw public irrigation initiatives stalled due to machinery breakdowns, high electricity costs, old and choked canals and poor service repayments. More recently, there is renewed effort by government to rehabilitate some existing irrigation schemes, leading to some of the abandoned schemes being brought back to production (Akrofi et al., 2019).

Food and Agriculture Organisation (FAO) estimates that Ghana's potential irrigable land amounts to about 1.9 million hectares (Mendes et al., 2014). The study also found that the irrigation potential remained largely undeveloped. Only about 1.6 percent (31,000 hectares) was under fully controlled irrigation, one of the lowest percentages in Africa. In order to realise this potential, it is suggested that interventions undertaken should concentrate on bringing existing schemes up to capacity before embarking on the construction of new schemes. Several studies point out the benefits of irrigation. Osei (2013) pointed out that irrigation is critical to achieve higher annual yields. Also, it is noted that achieving irrigation potential will help to improve agriculture and improve farmers' livelihoods since farmers can intensify and diversify their agricultural activities, and increase their overall production (Mango et al., 2018).

The management of irrigation schemes in Ghana have been faced with challenges such as poor record keeping and high operational and maintenance costs. Ghana's irrigation potential is highly untapped and underdeveloped hence efforts to rehabilitate as many schemes as possible are commendable. To augment government's efforts, we suggest an intervention that will be similar to the initiative by Government, and rehabilitate 10 irrigation schemes in Ghana (Bokpe, 2017). The Ghana Commercial Agriculture Project (GCAP) has an objective to rehabilitate and modernize 10 irrigation schemes which is expected to be completed within 18 months after the commencement of the project.

This intervention proposes to rehabilitate the following already existing irrigation schemes: Ashaiman, Dawhenya, Weija, Afife, Aveyime, Mankessim, Okyereko, Subinja, Sasta and Akumadan. Even though these are part of the Ministry's long-term plans, they are yet to be implemented. The total area to be covered by these 10 irrigation sites is 3,443 hectares. This hectarage is the summation of the potential area of the 10 irrigation schemes earmarked for rehabilitation and modernization. This was obtained from basic data from GIDA, (2018). The proposal will be to rehabilitate these irrigation schemes over a period of 30 months as compared to 18 months proposed by the Government for the other schemes. This is to cater for unforeseen challenges that may arise during the implementation phases; including institutional changes that are needed to make the Water Users Association (WUA) effective with governance and the collection of user fees. The performance of smallholder farmers' engagement in irrigation water management in the past has been poor and there have been several instances of default payments (Namara et al., 2011). Hence the intervention will include a mechanism that enbales farmers to pay flexibly so that they do not shy away from accessing these facilities. Additionally, this intervention assumes farmers will pay a service charge to sustain the irrigation schemes with farmers paying an amount commensurate with the amount of water used. Farmers will contribute towards the operation and maintenance costs of the project, making the overall government outlay requirements more realistic given limited fiscal space. According to Government, WUA exists to safeguard and sustain the various schemes. However, some institutional changes that could be key, involve the creation of a national federation of water users association to help manage and coordinate the work of the various associations (Bokpe, 2017).

One of the components of the Ghana Commercial Agriculture Project (GCAP) which is being implemented by the Government of Ghana (GoG) through the Ministry of Food and Agriculture (MoFA) is to invest in physical rehabilitation and modernization of selected existing public irrigation and drainage infrastructure. A key feature of the irrigation system under the GCAP is the installation of an automation system that controls the irrigation gates and ensures efficient use and management of water. This automation system has a remote terminal unit connected to gate measurement systems in the canals. Upon activation, farmers who need water will get it pumped to their farms immediately. Also the operating office of GIDA has a database that enables them to oversee activity on each irrigation scheme from across the country and determine how the farmers are using the water.

The schemes will imitate the management structure of existing irrigation schemes being handled by private sector under the regulation of the GIDA. The new operation and management model is envisaged to mitigate the problem of recurrent expenditure incurred by Government, almost every decade, on irrigation management in the country. It will ensure that the only burden on the government will be to repair the main canals every 30 years as there would be enough money generated by the various schemes to maintain the secondary and tertiary canals (Bokpe, 2017).

The institutional changes required to enable this intervention are a source of risk, given known challenges with this type of intervention in developing countries, including Ghana. However, this appears to have been mitigated to some extent with GCAP project – as previously mentioned, a similar initiative to the one described here. According to Koomson (2020), the project which involves the digitization of the Kpong Left Bank Irrigation scheme with an automation system is already about 63% complete.

There are two additional sources of uncertainty that one anticipates with this intervention. The first relates to the pricing of the water which will be done per litre as opposed to what has been done in the past – which was per hectare. A second source of uncertainty is the fact that the scheme will be under private management even though oversight will be by GIDA, as described earlier. Given that farmers are used to the old system, one anticipates some level of apprehension and possible cooperation issues from the farmers initially. This calls for education and sensitization of farmers on the operation of the new system. As part of the sensitisation farmers must be made aware of the benefits they stand to derive from the involvement of the private sector in terms of general efficiency of the system in the long term. We therefore allot a budget in our model for the education of farmers, and include this in the cost of rolling out this programme. It goes without saying that sub-standard and poorly constructed schemes would increase the need for rehabilitation and maintenance. This situation can affect the sustainability of the intervention and its expected impact. One way of ensuring that irrigation schemes are properly constructed is to purchase materials that are durable. Thus, the procurement for these materials must be handled efficiently and in a timely manner in order to avoid cost overruns and delays in implementation.

So in effect this intervention is about rehabilitating 10 irrigation sites to cover 3,443 hectares over a 30-month period. The auxiliary part of the intervention is the setting up of the WUA to manage the irrigation schemes and ensure that they are maintained and sustained. According to Bokpe (2017), it is expected that the dam will last about 30 years before any major repairs are needed on the canals. After 2.5 years of implementation, we model the benefits of improved irrigation schemes over an additional 8-year time line to be conservative, and based on the advice of MoFA.

Valuation of Benefits and Costs of Irrigation Intervention

Benefits of Irrigation Intervention

The crops modelled under this intervention are rice, pepper, okra and tomatoes. These are the crops that are usually grown under irrigation schemes in Ghana. Records for 2015 from Adongo et al. (2016) show that for Tono, Vea, Doba, Libga, Bontanga and Golinga the crops grown were rice, tomato, okra, onion and pepper. Again, MoFA Progress Report (2017) revealed that vegetables and cereals were the most dominant crops that are produced under irrigation (see appendix for key crop assumptions on output, hectares under rehabilitation, price and overall benefit).

The key benefit for this intervention is increased yields. The increase in yield will come from 2 main sources. First the increase due to the more efficient use of nutrients by the plants in the presence of water – here there is increased yield over a production cycle. The second source of the increase is due to the fact that with irrigation, a farmer can have two production cycles in a year. In that case the annualized yield also increases. In this report we assume the annualized yields increases by 100% - i.e. farmers can undertake two productions, instead of the one in a year.

Estimations from Adongo et al. (2016) reveals that a 20% increase in yield is likely to occur when land is put under irrigation schemes in Northern Ghana. An earlier study conducted by Siebert & Döll, (2010), also concluded that the world food production would increase by 20% when irrigated cropland replaces rainfed cropland. Additionally, according to the 2017 MoFA Progress Report, the cropped area under formal irrigation increased from 11,000 hectares in 2016 to 12,003 hectares in 2017. This change resulted in an increase in crop yield by 27%. For this intervention, the assumption is that yield per production cycle will increase by 20% by Year 5.

We also expect the annualised yield to increase by 2 times. The assumption here is that with irrigation farmers should be able to plant the crops about twice a year instead of the usual once under rainfed production. In some cases this may be an underestimate. For example, the intervention would ensure at least 3 major cropping seasons for maize farmers within a year.

By year 3, after full implementation the total benefit of increased yield is GHS 89.6 million, which increases slightly each year to account for real growth in price and output. By 2030, the total discounted benefits, at 8%, amount to GHS 513.9 million.

Costs of Irrigation Intervention

The implementation of the irrigation rehabilitation programme would have two major cost components. These are rehabilitation costs and maintenance costs. The government would bear the cost of rehabilitation of the irrigation schemes. The cost of rehabilitating an irrigation site is about GHS 104,000 (US$ 20,000) per hectare. According to Namara et al., (2011), the average cost per hectare of developing the irrigation schemes in Ghana is above GHS 78,000 (US$ 15,000). Taking into account inflation over the years, the cost of rehabilitation is estimated to be GHS 104,000 (US$20,000) per hectare in current prices. Given a size of 3,443 hectares, the the total cost amounts to GHS 360 million (US$69 million), spread over three years.

To ensure longevity and sustainability of the irrigation schemes, the farmers (beneficiaries) would be charged additionally, service fees to maintain the various irrigation schemes. Information was obtained from discussions with a member of the management team of Irrigation Company of Upper Regions (ICOUR) Ghana on the maintenance cost (service and operation charges) of irrigation schemes. Based on that data we note that farmers are charged a service fee of about GHS 200 per acre annually. This amounts to about GHS 500 (US$ 91) per hectare. Maintenance costs after rehabilitation are approximately GHS 2m per year.

By 2030 the total cost of this intervention, discounted at 8% is estimated to be GHS 347.6 million.

Discussions of the BCR

The value of the benefits is the value of increased annualized yields due to the intervention. The costs which had two components (fixed and variable) were also derived on a per hectare basis and grossed up to obtain the total rehabilitation and maintenance costs. We show the estimated benefits, costs and BCR estimations at the various discount rates in Table 6.

Table 6 The Benefits – Costs Ratio of the Irrigation Intervention

Discount Factor	Benefits (GHS million)	Costs (GHS million)	BCR
5%	621.65	370.01	1.68
8%	513.90	347.58	1.48
14%	361.83	309.15	1.17

Source: Author’s Own Computation

The estimates show that at the discount rates of 5%, 8% and 14%, the rehabilitation of the irrigation projects is beneficial. The BCR is 1.48 (at 8% discount rate) which is low compared to some of the other interventions discussed in this report. In addition it must be said that this project must be implemented cautiously to avoid cost overruns and also ensure that yield targets are achieved optimally to maintain the BCR above 1.

Our model estimates were reliant on three key parameters. First was the costs of rehabilitation per hectare which we assumed to be GHS 104,000 (US$ 20,000) and will cover an area of about 3,443 hectares for the 10 dams. This means that each dam will cost about GHS 35.9

million (US$ 6.9 million) to rehabilitate. Now if the rehabilitation is done more efficiently so that the cost per hectare is reduced, then the benefit-cost ratio would increase. Also the annualized yield is assumed to be 2 times the yield per production. For say, okra which has a cycle of about 12 weeks, this annualised production can be more than 2 times under irrigation. On the other hand, we have not incorporated the increased costs of production from additional cycles, which would increase the costs.

Implications for Policy

The rehabilitation of the 10 irrigation schemes proposed in this intervention is practical and feasible as our estimates show that the benefits outweigh the costs.

In order to ensure sustainability of the irrigation schemes, public private partnerships should be encouraged for optimum results. The development of local capacity to operate and maintain irrigation projects will also contribute to sustainability as proposed by Owusu et al., (2013). This can be achieved by running irrigation training programmes and creating strong linkages among local institutions, who are stakeholders in irrigation development. This could also have the added benefit of reducing the long run maintenance costs of these irrigation schemes.

Proper and frequent monitoring and evaluation (M&E) of these schemes will ensure that smallholder farmers are among the beneficiaries and that maintenance work is undertaken and in a timely manner.

Some of the cost elements can be further improved to make the irrigation even more affordable to the smallholder farmer. When the affordability and benefits-costs saliency is made more explicit to the farmer, it will result in increased and better use of irrigation schemes. For instance, as per the Copa Connect Initiative model by GADCO described in Osei (2013), farmers gained more interest in the initiative after they realised participating farmers had recorded increased yield and farm incomes.

Intervention V – Increased use of Mechanisation

Description of Intervention

The Problem

Ghana, like many countries in Sub-Saharan Africa, is largely dependent on agriculture for economic growth and development. Agriculture is an important sector among rural households, as the majority of households rely on it for their livelihoods. Again, as mentioned in the introductory part of this report, agriculture in Ghana is characterized by low productivity partly due to low public investment leading to low returns and consequently low incomes of farm households. In Ghana, modernization and intensification through expansion of mechanization among other technologies remain a key policy aim in the agricultural sector.

Mechanization, particularly access to tractor services, is essential for the expansion of area under cultivation and could lead to increases in crop productivity. However, access to mechanization or tractor services is low due to cost of services and in some cases unavailability of the services (Diao et al 2014; Benin et al 2011). This has meant that the use of holes, cutlasses and other manual implements dominates in the menu of tools used for agricultural production. The government reported in 2018 that there were 6200 tractors in Ghana (MoFA, 2018), and argued rightly so, that these were woefully inadequate for the agricultural sector of the country. It is estimated that out of the potential merchandisable agricultural land of eight million hectares, only 2.4 million hectares, representing about 30 percent are under mechanization (MoFA, 2018).

In recent times, there have been considerable investments in the expansion of agricultural mechanization through the Agricultural Mechanization Services Enterprise Centres (AMSEC) program. Based on the 2019 Budget Statement, Government of Ghana planned to spend about US$216 million for the importation of agricultural machinery (Ministry of Finance, 2018). In 2018, 212 tractor operators and mechanics including 62 women, were trained on effective handling and maintenance of agricultural machinery (MoF, 2018). Furthermore, the AMSEC program has expanded from the initial pilot program which was based in 12 centres in 2007 to 168 centres as at 2018 (MoF, 2018). As part of the AMSEC program, government provides subsidized agricultural machinery to private organizations and individual farmers with the aim of increasing farmers' access to mechanization services. This is supposed to help reduce drudgery, while expanding area under mechanized agriculture with expectation that yield will increases (Benin, 2015).

This section of the report seeks to examine the benefits and costs of expanding a mechanization intervention programme in Ghana, similar to AMSEC but that differs in two dimensions. First, our intervention provides an interest free loan rather than a pure subsidy for the mechanized asset. To make the tractors affordable to the private sector businesses, there is a "grace period" of three years where no interest payment is required. In addition, the tractor loan repayments are expected to be complete over the next four years, making the total repayment period seven years. We consider this variant because according to Hossou et al. (2016), private tractor service operators are more profitable than government subsidized AMSEC services. In addition, even without government subsidies (which was about 33 percent from 2007 to 2015), revenues generated by the private tractor service providers were sufficient to make them viable on-going businesses. Therefore, there appears to be an intervention available that can be more market driven than the AMSEC model, with the government stepping in only to procure tractors in large quantities and to provide credit to purchasers.

Second, our intervention focuses only on tractors whereas the AMSEC program is much broader as it includes other forms of the mechanization supply chain including ploughing, planting, harvesting, threshing, transportation, among others. The intervention essentially considers a large-scale expansion of a private ownership model, similar to that discussed in previous studies that have looked at the profitability of privately-owned tractors services (Hossou et al 2016; Hossou et al 2013).

In our anlaysis, we assume that the intervention leads to an increase in area under mechanization by 13 percent in total over the next ten years through purchasing of additional tractors and implements. This translates to 312,000 hectares or 31,200 hectares per year on average. This is assessed against a counterfactual of no increase in area under mechanization. Each tractor is assumed to have a useful life of 10 years, and therefore the time period of analysis is 20 years to ensure all benefits are captured from the intervention. The study uses Valtra tractor (75 horsepower) and three-disc plough which is the assumption used in other studies (Houssou et al 2016).

We focus on the impacts on maize production. Maize is the crop of choice for three main reasons: (1) it is the main cereal cultivated and also a major staple in Ghana; (2) it was the selected crop for other similar studies (Benin et al 2011; Benin et al 2015); and (3) the agronomic practices for maize cultivation make it easier to identify the effects of mechanization on the yield as maize farming in Ghana is mainly rain-fed and not under mechanization.

Due to mechanization we expect improvements in soil quality (soil moisture, water retention, air circulation, etc.) leading to higher plant growth and development, and subsequently higher yields. Benefits are estimated as the market price of increased output under mechanization. Costs concern the capital outlays and operating expenses of the mechanization services.

Valuation of Benefits and Costs of Mechanisation Intervention

Benefits of Mechanization intervention

The benefits stream is estimated as a product of three terms, namely;

- difference in yield with and without mechanization. Here we assume a yield increase of 11% due to mechanization equivalent to 0.22-0.26 tonnes per hectare over the time period of analysis (Benin et al. 2011).
- New hectares under mechanization, assumed to be 312,000 ha phased in over 10 years
- average price of maize, assumed to be GHS 1,924 (US$ 370) per tonne

Benin et al. (2011) document that yield gains from mechanization could be as high as 11%. Their estimates, based on a 2010 field survey data show that maize yield for the AMSEC beneficiary farmers averaged about 1900 kg/ha whilst that of non-beneficiaries averaged 1714 kg/ha – a difference of 186 kg/ha (11%). Furthermore, Benin (2015) found that AMSEC program farmers were 21 to 24 percentage points more likely to have a high perception of increased yield than their non-AMSEC counterparts. However, earlier studies by Panin (1995) and Binswanger (1978) found no statistically significant yield gains for farmers using tractor services.

To illustrate the benefits calculation, in the first year, an additional 139 tractors will be procured for use by private operators to cover a total area of 29,512 hectares. We make the assumption that even though the tractors will be purchased in year 1, the benefits will begin to accrue in year 2. Therefore in year 2 and based on a net change in yield of 0.22 tonnes per hectare, and at the maize price of GHS 1,924 per tonne, the total benefits that will accrue will be GHS 13.7 million. At the end of year 20 when all the tractors would have been phased out, the total discounted benefits (at 8%) of the intervention will amount to GHS 821.92 million (Table 7).

Costs of Mechanization intervention

The primary cost driver of the intervention is the cumulative area under mechanization due to the intervention. It is assumed that each tractor can plough 212 hectares per annum (Hossue et al. 2013). Given an increase of roughly 30,000 hectares of mechanized area per year, this implies the purchase of 139-155 new tractors annually.

The first cost considered is the capital outlay, assumed to be GHS 230,000 per tractor. This includes not only the tractors but also supporting investments such as a shed and driver registration. At an 8% discount rate, the capital investments represent 72% of the total cost.

The second cost considered is the operational cost which include overheads such as lubricants, business registration, fuel, personnel, and maintenance, among others summarised in Appendix Table 1. This represents 28% of the total cost with fuel and labor being the largest cost components. Over the entire life of the project the total discounted cost (at 8%) of this intervention is estimated at GHS 294.1 million (Table 7).

Discussion of the BCR

The mechanization intervention targets improvements in soil quality and area expansion under maize cultivation which will lead to higher productivity and production of maize. The benefit-cost analysis of the intervention is undertaken by looking at the various cost streams (for example, cost of purchasing the tractor and plough disc, repairs, operational costs including personnel, fuel and lubricants) and the associated benefits for using mechanization. In theory, there are multiple outcomes or pathways for mechanization to improve agricultural returns. However, this study only looks at improvement in yield and expansion in land area under mechanization. Estimation of costs and benefits are modelled using several secondary data sources discussed above.

The study finds that expanding mechanization is beneficial with estimated benefit-cost ratios (BCR) of 2.9, 2.8 and 2.2 at discount rates of 5, 8 and 14 percent, respectively. The BCRs obtained do not include additional benefits from improved quality of food (sensory) or health benefits, among others. If all these potential benefits are quantified, then one should expect that the BCRs would be higher than what has been estimated in this study.

Table 7 Estimated BCR of Mechanization in Ghana

Discount Factor	**Benefits (GHS Million)**	**Costs (GHS million)**	**BCR**
5%	1,107	388	2.9
8%	822	294	2.8
14%	482	220	2.2

Source: Author's Own Computation

As previous studies have shown, introducing labor-saving technologies including mechanization could lead to a potential negative externalities on labor market outcomes, with large effects on poor households dependent on casual or low skilled labor for their livelihoods (see Gallardo and Sauer, 2018). Under those conditions failure to account for such potential negative effects could lead to an upward bias of the estimated BCRs. Therefore, studies might consider the expected cost of displaced labor as a result of the introduction of the labor-saving technologies.

However, in this study we do not include potential labor displacement as a cost in the main analysis due to the following reasons: First we believe that any job losses would be small relative to the total demand for labour. According to Ngeleza et al. (2011), labor requirements for maize production range from 295 person-hours per acre to 531 person-hours per acre depending on cropping systems. In addition, use of mechanization (i.e. tractor services) could reduce labor use for land preparation per acre for maize by about 46 percent (Ngeleza et al. 2011). Using these assumptions (including the midpoint of person hours required for manual labuor), the annual incremental displacement from the intervention is only around 0.06% of annual working hours in the country. Therefore, one would expect the economy to adapt to this relatively small change, and any losses would likely be offset by gains in other parts of the economy such that the equilibrium welfare effects are zero.

Further, we expect that a country should be striving to increase efficiency such that costs of production (including labor) decreases over time. One might even argue that the labor savings are a benefit, especially if labor is scarce. Supporting this notion is Ngeleza et al. (2011), who state that due to "unavailability and cost of labor, farmers are increasingly demanding mechanical traction for land preparation in Ghana". However to ensure consistency in the estimations and to also address the negative implications for casual labor, these labor savings are not included as a cost nor a benefit in the base case.

As a final check of the importance of this assumption, we conduct a sensitivity analysis by including job displacement as a cost. Assuming a monthly wage rate for skilled agricultural and fisheries workers at GHS 1,068 (Ghana Statistical Service, 2019), the result shows that even with this additional cost it is still beneficial to expand mechanization services in Ghana. In addition, using the rate for skilled workers which is much higher than unskilled workers still show that the estimated BCRs are greater than 2.

Implications for Policy

This study estimates the cost-benefit ratio of expanding mechanization in the agricultural sector of Ghana. The main aim of this intervention is to expand area under cultivation being mechanized through providing tractor (mechanization) services. This intervention is an expansion of existing privately-owned mechanization services in Ghana. The estimated BCRs of over 2 based on various discount rates (discount rates of 5%, 8% and 14%), show that it is beneficial to expand mechanization in Ghana. The results show lower BCR compared to Benin et al (2011) who obtain a BCR of 4.3 for AMSEC.

The main policy implication based on the results for this intervention is that current efforts in expanding access to mechanization need to be intensified in order to improve agricultural productivity and returns in Ghana. We note in particular that for this model the effectiveness of the mechanization intervention is very much dependent on the profitability of the smallholder farm. An area for future research will be to undertake analysis on expanding mechanization services for the entire value chain or potential mechanizable area under cultivation.

Intervention V – Building of Warehouses

Description of Intervention

The Problem

A World Bank report disclosed that in Sub-Saharan Africa (SSA), a large amount of food produced (particularly grains), is lost after harvest with an estimated value of US$ 4 billion (World Bank, 2011). For this reason, investing in post-harvest loss reduction is potentially a smart and impactful intervention to ensure food security (GIZ, 2013a). The narrative on post-harvest losses in Ghana is no different. Ansah and Tetteh (2016) recognize the need to reduce post-harvest losses as an essential means of improving food security in the country and one way to minimize post-harvest losses is to manage storage losses. It is expected that when post-harvest storage losses are well managed, farmers will be able to keep their produce for a long time without significant losses, and will be able to sell at good and attractive market prices. Also for subsistence farmers, minimizing post-harvest losses is a way of making sure food is available all year round (Ansah et al., 2018). Hence a reduction in post-harvest losses provides a significant pathway of reducing poverty and improving nutrition.

Improving food security through a reduction of post-harvest losses is also imperative for meeting current development objectives of the Ministry of Food and Agriculture in Ghana since losses reduce real income for all consumers, divert essential income out of farmers' pockets and undermine overall food availability (Opit et al., 2014). The upsurge in the Ghanaian population coupled with losses in food supply exacerbates malnutrition and hunger. Futhermore, large post-harvest losses increase the required area under cultivation, relative to a lower loss situation. This exacerbates environmental challenges (GIZ, 2013b, Hodges et al., 2011).

The major cereal grain consumed in Ghana is maize and it is considered the most important cereal accounting for 50-60% of the total cereal production (Ragasa et al., 2014). Lack of storage intrastructure is one of the key challenges facing smallholder maize farmers in Ghana. Smallholder farmers store maize using traditional grain storage structures and woven polyethylene bags but these forms of storage are unable to prevent insect infestation. Because of the risks associated with grain storage, farmers try to minimize losses by selling their grain soon after harvest, leading to low market prices as the markets are flooded with freshly harvested grains (Opit et al. 2014). Conversely during the off-season, the price of maize is usually highest as maize is not easily available. According to Bruce (2016), Ghana loses about 318,514 tonnes of maize annually to post-harvest losses, equivalent to about 18% of the country's annual maize production. Improving food security particularly for the poor, will be difficult to accomplish without sufficient maize storage so as to stabilize prices during the off-season. Also, maize could become an economically important export commodity for the country if it can be stored appropriately.

In the PFJ document – "Strategic Plan for Implementation (2017-2020)", the Government is hoping to build 86 new medium sized warehouses and also rehabilitate 130 existing warehouses. This number may be large but will still not be enough to reduce the post-harvest losses in Ghana in a significant way given their collective capacity. We therefore suggest an intervention that will add considerable post-harvest capacity to that which is planned by government.

Table 8 List of Certified Warehouses by Ghana Grain Council

Warehouse	Region	Municipal/ District	Community	Warehouse Capacity (MT)
Grain Leaders Ltd.	Brong Ahafo	Nkoranza South District	Nkoranza	500
Wienco (Ghana) Ltd.	Northern	Tamale Metro.	Lamashegu	18,000
Gunda Produce Company Ltd.	Northern	Tamale Metro.	Datoyili	500
Savanna Farmers Marketing Company Ltd.	Northern	Tamale Metro.	Chanzini	1,000
CDH Commodities Ltd.	Greater Accra	Accra Metro.	Avenor/ Circle Close	4,600
AGMSIG Resource (Shekinah ABC)	Northern	Tolon District	Nyankpala	1,000
BUSACA Agribusiness Company Ltd.	Northern	Savelugu District	Savelugu	1,000
Premium Foods Ltd.	Ashanti	Kumasi Metro.	Jachie-Pramso	18,000
Faranaya Agribusiness Co. Ltd.	Northern	West Mamprusi District	Walewale	1,000
Greater Accra Poultry Farmers Association (GAPFA)	Central	Gomoa-Akotsi	Gomoa-Akotsi	3,000
Total				54,600

Source: Ghana Grain Council (2018)

Table 8 demonstrates that existing warehousing capacity was about 55,000 tonnes as at 2018, with large variation in warehouse sizes. Large warehouses exist in metros of Kumasi and Tamale, with smaller warehouses in other locations. The model capacity for each warehouse is 1,000 tonnes.

The intervention will look at constructing 46 new warehouses with an average capacity of 1,000 tonnes over the next 3 years. Specifically, the proposed intervention will start with 20 warehouses in 2020. An additional 20 warehouses will be constructed in 2021 and the remaining 6 will be built 2022. These new warehouses will supplement government's effort in curbing post-harvest storage losses and significantly boost the nation's total warehousing capacity. It must be noted that even with the proposed intervention of additional warehouses, only a small fraction of post-harvest losses can be addressed.

Although the construction of warehouses will help curb the issue of post-harvest losses, the risks and uncertainties associated with storage in warehouses should not be ignored. These risks are associated with theft and fire outbreaks among others. In the warehouse, the stored produce can also deteriorate under certain conditions that enable moulds, pest and aflatoxin levels to increase and make the produce not safe for human consumption. Hence, warehouse operations should be discharged effectively and requires the recruitment of experts and the training of warehouse operators to effectively manage the warehouses (Dunakin, 2020).

The storage environment must also be protected from all forms of environmental hazards that would be detrimental to the agricultural produce. There are certain designs and approvals needed for the construction and running of a warehouse in Ghana and this can be obtained from the Food and Drugs Authority (FDA). The event of offering contracts to unqualified personnels will have adverse implications for both the short and long term. This is because wrong construction can expose the agricultural produce to high humidty, poor ventilation, microbial and pathogenic attacks which result in great post-harvest losses and defeats the purpose of setting up these structures. This will also lead to higher maintenance and renovation costs which will be avoided if it was done right from the initial stage. Storage facilities should therefore be set up properly and under strict supervision using a qualified work force.

The sustainability of the warehouse might be a problem if operations are not run effectively. To ensure that there are enough funds to run the warehouses, they have to be operated at near to full capacity. To achieve this, other crops can be gradually introduced to the warehouse system to ensure that the system is still running even when maize is out of stock. Also there will be the need to add on other relevant functions aside the storage of maize. Add-on services such as packing, processing, grading, aflatoxin tests etc should also be run alongside to generate enough revenue since service charges for storage of maize in warehouses are minimal (a monthly charge of GHS1.00 per bag of maize stored in the warehouse).

Valuation of Benefits and Costs of Warehouses Intervention

Benefits of Warehouses Intervention

The benefit of this intervention is the value of post-harvest losses avoided. There is an additional benefit in terms of stability and reduction of prices over time, but this was not estimated in this analysis. In terms of modelling, we essentially capture and value the benefits as a reduction in post-harvest losses associated with the building these 46 warehouses by 2029. As stated earlier, post-harvest losses amount to about 18%. It is expected that this figure will reduce to about 5% with the warehouse intervention. This figure makes room for inefficiencies that are still inherent in the storage system. Given that each warehouse can hold 1000 tonnes, the expected post-harvest storage loss avoided is around 6,000 tonnes per year in steady state.

Applying a value per tonne of $370 per tonne, and decreasing 1.2% per year to account for increased supply arising from the intervention, the total benefits for the 15 years of the project life amount to GHS 90 million, using a discount rate of 8%.

We also model the effect on prices of maize output. Without storage, instead of the normal trend where prices increase from one year to another, we assume that this intervention stabilizes the prices of maize initially before falling slightly over time. The stability in maize prices can be attributed to the all year-round availability of maize. During the lean season, prices shoot up while prices are very low during the bumper season due to excess supply. Storage will therefore help to regulate demand and supply of maize which will result in the stability of maize prices.

As with other interventions, there are indirect benefits which are not captured by the calculations. For instance, one notes that the intervention will create both on and off farm employment opportunities through activities such as purchasing, sale, preservation and distribution of food stuffs. Another potential benefit for farmers is that the warehousing receipting system can be used as a way of improving farmers access to credit. These potential benefits are not easy to model but certainly worth noting. Also, warehousing will result in the reduction of aflatoxins. The control of aflatoxins will help to solve the problem of reduction in food quality during the post-harvest period

Costs Warehouses Intervention

The implementation of the intervention will have a number of key cost items. These will include the cost of constructing the warehouses, maintenance cost, handling and administrative cost, warehousing insurance as well as the cost of employing caretakers, aggregators and sub-aggregators. All of these are estimated using figures from other studies. The important cost assumptions include:

- The unit cost of a new warehouse is GHS 460,000.00. This estimate was obtained from government's document on Planting for Food and Jobs (MoFA, 2017) and is consistent with that used in Government's budget allocation for the Planting for Food and Jobs Programme (PFJ).

- The average handling and maintenance cost is GHS 3 per 100kg per year (Benin et al 2011). This means each 1000 tonne capacity warehouse will cost about GHS 30,000.00 to maintain. A capacity of 1000 tonnes is proposed since most of the certified warehouses currently used by the Ghana Grain Council is about 1000 tonnes.
- Warehousing Insurance cost of GHS 2 per 100 kg per year (Benin et al 2011) is used. This translate to GHS 20,000.00 for each 1000 tonne capacity warehouse.
- Aflatoxin test is done on demand and costs GHS 120 per sample. It is assumed that the testing is done once a year in each of the operational warehouses. Resource personnel in the field of warehousing provided this information in the year 2020 since there is no literature on aflatoxin cost in Ghana.
- Transportation cost is GHS 5 for an 80kg bag of maize. This information is obtained from personnel working with Ghana Grains Council and the Ashaiman Cargo Branch of the Ghana Private Road Transport Union (GPRTU).

By Year 3 when all the 46 warehouses have been built the total cost of the intervention will amount to GHS 6.5 million for that year. For the entire 15 years, which we assume will be the life of the project, the present value of the total costs is obtained as GHS 49.2 million, using a discount rate of 8%.

Discussions of the BCR

The calculations show that the BCR for this intervention is low compared to some of the other interventions. At the discount rates of 5%, 8% and 14% we get ratios of 1.95, 1.83 and 1.62 respectively (Table 9). These results are sensitive to a number of parameters; two of which bear mentioning. First, we modelled the cost as GHS 460,000 per 1000 tonne capacity warehouse. If we were to improve the efficiency of constructing warehouses so that, for instance the capacity of the warehouse increased to 1500 tonnes for the same costs, this will increase the BCR (5% discount rate) by about 16% from 1.95 to 2.27. Second, if the reduction in post-harvest losses were to change the BCR will also change. For instance, if the reduction in post-harvest losses were to reduce to 10% instead of the 5% assumed, the BCR will reduce by about 39% - at 5% discount rate, from 1.95 to 1.2.

The uncertainties that may prevent achievement of the proposed targets are efficiency of human resource and the procurement strategy employed during construction. It will be laudable if key players responsible for construction can exceed the potential capacity of 1,000 tonnes per warehouse with the same budget. This can only happen if procedures are carried out effectively and efficiently. Also, efficiency in the operation of the warehouse can be a key factor accounting for an increase or decrease in storage losses. Hence, employing qualified staff and ensuring that appropriate procedures are followed strictly will help to reduce these losses greatly.

Table 9 Estimated BCR for Warehouse Intervention

Discount Factor	Benefits (GHS million)	Costs (GHS million)	BCR
5%	**112.71**	**57.94**	**1.95**
8%	**90.01**	**49.17**	**1.83**
14%	**60.44**	**37.40**	**1.62**

Source: Author's Own Computation

Generally, the benefit-cost ratio does not change even if we achieve only 50% of the scale of the intervention. This is essentially because we do not build in the model economies of scale so that larger capacity is associated with lower average costs. This will suggest that the benefit-cost ratio estimated can be considered as a minimum for the given parameters.

Implications for Policy

The results suggest that the intervention is beneficial as the benefits exceed the costs. However, compared to some of the other interventions, the expected returns with these warehouses' investments are not as high. This is however not to suggest that the intervention is not necessary or the problem of post-harvest can be ignored. Rather it highlights the fact that we need to investigate and find a better and more cost-effective technology for the building of warehouses to ensure that it appropriates good returns on the investment. Indeed, as we discussed above, if we improve efficiency of building the warehouses (bigger capacity for same costs) and/or improve the efficiency of the operations of the warehouses (maximum reduction in post-harvest losses) then we can improve the case for this intervention.

Conclusion

The key question that we sought to answer with this agricultural priority project was that if the government hypothetically had millions of additional cedis to spend, which intervention should the government prioritise over the many challenges in in the agricultural sector of Ghana? To do this, Benefit Cost Analysis (BCA) was conducted on five interventions within the sector. The interventions analysed included, 1) subsidization of Improved seeds intended to increase access and use of improved seeds for higher productivity; 2) Fertiliser subsidies, aimed at improving the suboptimal fertiliser use among farmers and to enhance productivity; 3) Irrigation, also aimed at rehabilitating 10 irrigation schemes in Ghana to reduce the proportion of farms under rain-fed agriculture; 4) Mechanisation, focused on increasing farmers’ access to tractor services to expand area under mechanized agriculture and increase yields; and finally 5) Building of warehouses, aimed at constructing 46 new warehouses for storage of maize to help reduce postharvest losses.

The analysis was done based on different assumptions and parameters for the various interventions. The cost involved in the implementation of any of the interventions is to be borne by both government and individuals, though government bears the greater part of it particularly capital outlays. In terms of benefits, productivity increases and post-harvest loss reduction, culminating in higher revenues were the main benefits modelled for all the interventions. These benefits accrue to both the state and individual smallholder farmers since increased productivity and revenue trickles down to both food and income security for the economy, as well as increasing agriculture GDP.

It is important to highlight that all the interventions analyzed recorded a BCR value of greater than 1, implying that all interventions assessed were viable and promised positive returns when implemented. However, the magnitude of the returns differed as some interventions had higher BCR values compared to others. The most promising interventions were subsidising hybrid seeds and fertilizer. These had higher BCRs of 3.6 and 4.4 respectively at an 8% discount rate. This is followed by mechanisation programme (2.8), OPV seeds (2.3), the warehousing intervention (1.8) and the irrigation intervention (1.5) in that order. We suggest not putting too much weight on the absolute magnitudes due to inherent uncertainties in the analyses, and only some weight on the relative BCRs. That said, it appears that encouraging farmers to use hybrid and fertilizer inputs via subsidies would be more efficient than other interventions.

The greatest source of uncertainty, and the one that would arguably change the policy implications the most is the assumed extent and waste associated with smuggling of subsidized seed and fertilizer, particularly the latter. We have attempted to account for these in our analysis using actual expenditure data from government sources. However, one might argue that even if smuggled, as long as the inputs are used, benefits will accrue – though of course not to the intended beneficiaries and perhaps not even for Ghana.

We note that we have only undertaken the analysis at the 'individual' level and assumed away complementarities. Incorporating complementarities may change the overall returns to these interventions in a favourably way, we believe.

The agricultural sector in Ghana has the potential to grow in spite of the challenges that has bedevilled the sector. What the BCR report has shown is that, each of the interventions is important on their own merit. We have seen that investments in these interventions on their own prove to have positive returns. However, and indeed for any agriculture intervention, complementarities remain important and so while the report makes a case for these interventions as outlined in the government's policy documents, a more holistic approach will maximise the growth dividend for the economy as a whole.

Table 10 Benefits Cost Ratio of all Agriculture Interventions

Intervention	Discount Rate	Benefit (GHS millions)	Cost (GHS millions)	BCR	Quality of Evidence
Improved Seeds Under the Planting for Food and jobs	*Hybrid - 5%*	2127	587	**3.6**	Medium
	Hybrid - 8%	1750	490	**3.6**	
	Hybrid - 14%	1248	358	**3.5**	
	OPV - 5%	1403	603	**2.3**	
	OPV - 8%	1163	511	**2.3**	
	OPV - 14%	840	382	**2.2**	
Fertilizer subsidy for 5 years followed by 5 years phase out	*5%*	2,328	526	**4.4**	Medium
	8%	2,011	460	**4.4**	
	14%	1,555	363	**4.3**	
Rehabilitate 10 irrigation schemes covering 3,443 ha	*5%*	622	370	**1.7**	Medium
	8%	514	348	**1.5**	
	14%	362	309	**1.2**	
Increase area under mechanization by 13% over 10 years	*5%*	1107	388	**2.9**	Medium
	8%	822	294	**2.8**	
	14%	482	220	**2.2**	
Increase maize warehouse capacity 46,000 tonnes	*5%*	113	58	**1.9**	Medium
	8%	90	49	**1.8**	
	14%	60	37	**1.6**	

Source: Authors Computation, 2020

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Appendix

Appendix Table 1 Assumptions on Tractor and Plough, Prices and Operating Costs

Item	Measurement	Value
Tractor and implement	One Valtra tractor (75 horsepower); one three-disc plow	US$ 39500 (2016 CIF price)
Interest rate on tractor	Rate	10%
Grace period on interest payment	Years	3
Expected tractor repayment period	Years	7
Tractor field capacity	Hectares per day	4
Tractor and plow/plough lifetime	Years	10
Annual tractor & plow depreciation	Rate per initial investment	10%
Fuel consumption per acre	Gallons per acre	1.5
Fuel price per gallon (YEAR)	GHS	GH¢ 13.5
Lubricant costs as percentage of fuel costs	Rate	15%
Maintenance and repair costs	Rate per new tractor & implement price	1%
Tractor shed building costs (YEAR)	GHS	GH¢ 1,400
Shed useful life	Years	10
Annual shed depreciation	Rate	10 percent of shed building costs
Comprehensive insurance per year (based on YEAR prices)	GHS	GH¢ 571.02
Business registration (one-time)	GHS	GH¢ 100
Business renewal fees per year	GHS	GH¢ 20
Casual labor wages (one operator and one assistant) for plowing per hectare	GHS	GH¢ 20
Tractor registration at Driving License Authority	GHS	GH¢ 62.70 (one-time payment)

Source: Houssou et al 2016; Hossou et al 2013; authors' calculation based on prevailing market conditions.

Appendix Table 2 Key crop assumptions for irrigation intervention

	Price per MT (US$) in 2023	**Rehabilitated area (ha) in 2023**	**Output increase (MT) in 2023**	**Value of increased production in 2023 (US$, millions)**
Rice	529	329	1,279	0.68
Tomato	420	1498	16,861	7.09
Pepper	368	810	9,926	3.65
Okra	342	807	10,472	3.58

Source: MoFA Progress Report (2017)

GHANA PRIORITIES

The Ghanaian economy has been growing swiftly, with remarkable GDP growth higher than five per cent for two years running. This robust growth means added pressure from special interest groups who demand more public spending on certain projects. But like every country, Ghana lacks the money to do everything that citizens would like. It has to prioritise between many worthy opportunities. What if economic science and data could cut through the noise from interest groups, and help the allocation of additional money, to improve the budgeting process and ensure that each cedi can do even more for Ghana? With limited resources and time, it is crucial that focus is informed by what will do the most good for each cedi spent. The Ghana Priorities project will work with stakeholders across the country to find, analyze, rank and disseminate the best solutions for the country.

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