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Smallholder Farmers' Profit Margin on Sustainable Land Management Practices in Ghana

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Abstract: Cereal crop yields have declined over the years due to mainly declining soil fertility. In the context of other stressors such as climate change, declining yields continue to have negative effects on food security and environmental sustainability. In many small-holder farming across the developing world including Ghana, the emphasis has shifted towards sustainable land management practices for soil fertility improvement in farming. While the approach has gained popularity in policy circles, the profitability of these practices is not clearly understood especially among smallholder farmers. In this paper we used quantitative methods to explore the profit margins on the use of three sustainable land management practices-animal manure, compost and minimum tillage in two Districts of semi-arid northern Ghana to advise agricultural policy. Our findings were that, farmers largely use sacks and head pans in the application of animal manure and compost including the hiring and borrowing of other tools. Minimum tillage application requires mainly Knap sack sprayers and weedicides. The estimated mean cost of these tools for the application of the respective practices were Ghana cedi (GH¢) 449.2, 467.56 and 131.73 for animal manure, compost and minimum tillage respectively. The profit margins as well as sensitivity analysis of the practices were carried out using partial budget analysis. The results showed profit margins of GH¢ 448.2, GH¢327.5 and GH¢98.2 per acre per production season for animal manure, compost and minimum tillage respectively compared to GH¢15.3 when the farmer is not applying any of the three practices. The study concluded by recommending that small holder farmers should be provided with guaranteed markets for their produce and demonstration fields should also be encouraged to increase profitability of small holder farmers' investment on the land.

Keywords: Animal manure; compost; minimum tillage; cost; profitability; sensitivity; smallholders; sustainable land management practices.

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1. Introduction

Agriculture in sub Saharan Africa is dominated by smallholder farmers who rely mainly on family labour (Frelat et al., 2016; Hilson, 2016; Jayne et al., 2010; Sims and Kienzle, 2016). In the past few decades, the performance of the agricultural sector in sub-Saharan Africa is below potential (New Partnership for African Development, 2013; World Bank, 2006a). Reducing food insecurity requires increased food production which in turn necessitates ensuring that farmers' have improved access to productivity enhancing inputs; knowledge, skills and expansion of farm size (Theriault et al., 2018; World Bank, 2006a). Farmers in developing countries however, lack access to inputs and product markets as well as financial resources to procure costly agrochemicals to enhance the productivity of their lands (Kassie and Zikhali, 2009).

In Ghana, Most farms about 90% of all farms in the country are less than two hectares (less than 5 acres) indicating that smallholder farmers dominate the agricultural sector (Ministry of Food Agriculture, 2011). In the Upper West Region in particular where over 80% of the inhabitants depend on small holder agriculture, pressure on agricultural land has had negative implication on soil fertility and crop productivity (CIKOD and PFAG, 2018). Like other regions in northern Ghana population density has increased steadily per square kilometers from 24 to 31 and 38 in 1984, 2000 and 2010 respectively (Ghana Statistical Service, 2013; Ghana Statistical Service, 2012). It is expected that the region's population density will rise considering an inter-

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censual growth rate of 1.9% (Ghana Statistical Service, 2013; Ghana Statistical Service, 2012).

Moreover, large scale land grabbing and increasing urbanization in urban and peri-urban areas have further put pressure on agricultural land in rural areas (Kansanga et al., 2018; Kuusaana and Eledi, 2015; Nyantakyi-Frimpong and Bezner Kerr, 2017), with evidence of increasing land boundary conflicts in recent times (Kansanga et al., 2019).The high dependence on agriculture coupled with the increasing population density has led to continuous overexploitation of the soil resource making it difficult to maintain adequate fallows (CIKOD and PFAG, 2018; Becx et al., 2012; Fosu et al., 2004). Empirical evidence from the northern savannah suggests that, farmers have resorted to continuous cultivation due to increasing pressure on agricultural land and tenure insecurities (Kansanga et al., 2018; Jaiyeoba, 2003; Shehu et al., 2019; Shoyama et al., 2018). Ultimately, productivity tends to decline largely due to low organic matter content in the soils. The amount of organic matter in the field indicates the soi health, as it serves as a biological pool for major plant nutrients (Sustainable Development Solutions Network, 2013; Baldwin, 2006).

Also, agriculture in the savannah zone is dominated by slash and burn, improper rotation, overgrazing and uncontrolled bushfires. These practices deprive the soil of organic materials making the soil insensitive to even the application of inorganic fertilizers in extreme cases (Kassie and Zikhali, 2009). In many parts of sub Saharan Africa including Ghana, despite the implementation of fertilizer subsidy programs, the majority of smallholder farmers are still unable to procure the subsidized fertilizers (Druilhe and Barreiro-Hurlé, 2012; DID, 2004; DID, 2001). In the context of the worsening edaphic factors couple with climate variability, the government of Ghana and development organizations in most developing countries has increasingly promoted Sustainable Land Management Practices (SLMPs). Food Agriculture Organization (2011) explained that, the application of animal manure, compost, zero/minimum tillage, and integrated crop livestock system can reduce soil fertility decline and increase productivity. Maize yield increases of between 93%-400% have been reported across Africa with various SLMPs (FAO, 2011; Pretty, 2006).

Although, SLMPs are observed to be low cost innovations, relatively easy to implement and technically supported to an extent (Dallimer et al., 2018; Kassie et al., 2010), large scale use of these SLMPs is not clearly understood. Some aspects of socioeconomic and biophysical factors have been reported to affect the usage of SLMPs in parts of Africa (Kassie et al., 2012; Teklewold et al., 2012; Akudugu et al., 2012; Nkala et al., 2011). Unraveling these smallholder farmers' cost and benefits associated with the use of these SLMPs especially in the semi-arid northern savannah is worth exploring to enhance large scale use of SLMPs. The understanding of the cost and benefits to be driven by the smallholder farmer' in the usage of the respective SLMPs will help inform agricultural policy targeted at increasing SLMPs use among smallholder farmers.

2. Materials and Methods

2.1. Theoretical Framework

Generally, consumer demand studies have shown that, consumers generally have subjective preferences for characteristics of products and their demand for products is significantly affected by what they have seen and heard about the product (Adesina et al., 1995). In the perspective of consumer behaviour, a rational farmer will seek to maximize his or her own wellbeing through the choices he or she makes on crops and inputs given the land, labour and capital they can access (Varian, 2010). The attitude of the farmer towards risk is also an important factor in their decision-making. Though general trend exist, the alternative in the event of crop failure is particularly useful in improving smallholder farmers' productivity (de Janvry et al., 1991). This means that a small holder farmer applies a mix of practices to deal with a multitude of agricultural production constraints. This study therefore adopts a partial budgeting technique, which estimates the additional cost or benefits added as a result of changes in some production processes (Gittinger, 1984).

2.2. Study area

The study was conducted in the Wa East and Lawra Districts of the Upper West Region, Ghana. The Lawra District reports lower cereal crop yields while the Wa East District reports higher cereal crop yield. The selection of the two diverse contexts will uncover smallholder farmers' view of SLMPs as shaped by their different environmental conditions. Data was collected in December, 2017 during the dry season in the northern savannah zone when farmers are less busy with their farm work. The Upper West Region covers a geographical area of approximately 18,478 square kilometers representing about 12.7% of the total land area of Ghana.

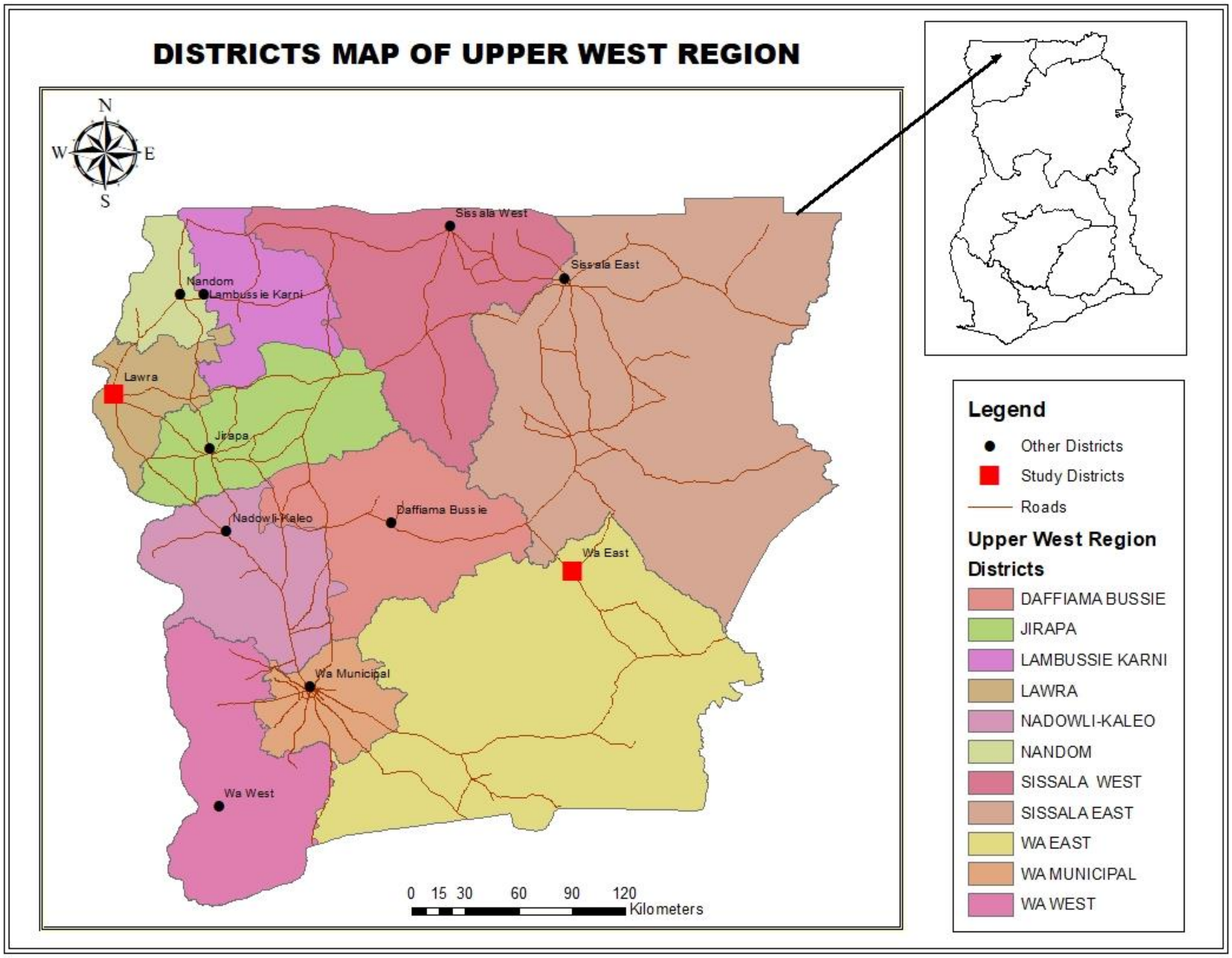

Fig. 1. Map of Upper West Region, Ghana.

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It is bordered to the North by the Republic of Burkina Faso, to the East by Upper East Region, to the South by Northern Region and to the West by Cote d'Ivoire. Upper West Region was carved out of the then Upper Regions in 1983. It has the lowest population of 702,110, representing 2.9% of the country's total population of 24.2 million. The Region's population growth stands at 1.9% (GSS, 2012; FAO, 2011). Figure 1 shows a map of the Upper West Region with eleven districts. The two study districts are dotted orange colour as shown in Fig.1. The Region is located in the guinea savannah zone consisting of grassland. The land is covered with scattered drought resistant trees such as the Shea trees, the baobab trees, African Locust bean trees (dawadawa), and neem trees. The heterogeneous collection of trees provides all domestic requirements for fuel wood and charcoal, construction of houses, cattle kraals and fencing of gardens. The shorter shrubs and grasses provide fodder for livestock (GSS, 2012). The climatic regime is semi-arid with annual rainfall of 900mm – 1200mm. The region experiences two seasons each year, the dry and the wet seasons. The wet season commences from early April and ends in October. The dry season is characterized by the cold and hazy harmattan weather (Kansanga et al., 2019). It starts from early November and ends in the latter part of March when the warm weather begins. The intensity of the warm weather ends only with the onset of the early rainfall in April. The mean monthly temperature ranges between 21°C and 32°C (GSS, 2012).

Table 1. Sample Size

Lawra District		**Wa-East District**	
Community	Respondents	Community	Respondents
Baazing,	16	Bufiama,	16
Bagri	16	Ducie	16
Kalsegre	16	Funsi	16
Lissa	16	Kpaglahi/ Kpalinye	16
Tanchara	16	Kundugu	16
Yagra	16	Loggu	16
Yikpee	16	Manwe	16
Zambo	16	Yaala	16
Total	**128**	**Total**	**128**

Temperatures rise to their maximum (40°C) in March, just before the onset of the rainy season, and fall to their minimum (20°C) in December during harmattan which is brought about by the North-East Trade winds. The Region has an almost entirely flat topography, especially west of the capital of Wa and around Lawra, better referred to as the Wa-Lawra plains. The height of the land is generally between 275m and 300m above sea level, except eastwards of Wa where the land rises over 300m above sea level. Further eastwards, the land falls to about 150m above sea level (NEPAD, 2013; GSS, 2012).

2.3. Data and Sampling

This study employs a multistage sampling technique. A stratified sampling technique was employed in sampling communities for the study. The District Agricultural offices classified each District into Extension Areas commonly known as EAs. Among the Extension areas, at least one community was randomly selected from each Extension Area (EA) depending on the number of communities in the Extension Area (EA). This gave us eight communities in each District giving us a total of 16 communities in both Districts. The following communities were therefore selected as a result, Baazing, Bagri, Kalsegre, Lissa, Tanchara, Yagra, Yikpee and Zambo from the Lawra District. Communities from Wa East District included Bufiama, Duccie, Funsi, Kpaglahi/Kpalinye, Kundugu, Luggu, Manwe and Yaala. The sample frame included all smallholder farmers in these communities. The targeted group was smallholder farmers who cultivate cereal crops particularly maize, sorghum and millet. Smallholder farmers were chosen because they constitute large percentage of farmers within the Region and the country at large. This category of farmers are also largely affected following any major change in farm policy. The study equally considered cereal crops particularly maize, sorghum and millet, which are widely cultivated and consumed in the Region (NEPAD, 2013).

2.4. Measurement Technique

This study employs a questionnaire for the collection of data on all the other aspects of the study. The first part collected information on the type of tools required for the application of the respective practices i.e. animal manure, compost and minimum tillage. The prevailing cost prices for each of the tools in the neighbouring markets were obtained as part of the survey. The total costs for the respective set of tools for each of the practices were estimated. The mean cost of tool required for applying each of the practices i.e. animal manure, compost and minimum tillage was then computed in line with the response from the questionnaire. Partial budget analysis was employed in analysing the profitability of each of the practices. Gittinger (1984) explained that partial budget is most appropriate for analysing the profitability of farm business in which changes were added to certain aspects of the production process but not the entire farm business. Table 2 describes partial budget used in the profitability analysis.

Table 2: Partial Budget for Alternative SLMPs

A. Added Costs	**Cost in GH₵:**	**B. Added Returns**	**Benefits in GH₵:**
Activity/Item1	X	Activity/Item1	X
Activity/Item2	X	Activity/Item2	X
Activity/Item3 etc.	X	Activity/Item3 etc	X
C. Reduced Returns	**In GH₵**	**C. Reduced Cost**	**In GH₵**
Item/Activity 1	X	Item/Activity 1	X
Item/Activity 2	X	Item/Activity 2	X
Item/Activity 3 etc.	X	Item/Activity 3 etc.	X
A. Total Costs	**X**	**B. Total Benefits**	**X**
C. NET CHANGE IN PROFIT = Total benefits – Total costs or (F−E)			

Source: New Jersey Department of Agriculture (2001). Exchange Rate: 1 dollar = 4.6 Ghana cedi (GH₵)

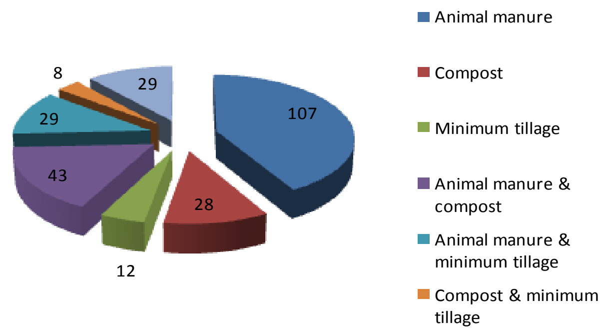

Fig. 2. SLMPs used and Their Frequencies from Data Source: Field Survey (December, 2017).

Sensitivity analysis was carried based on the average inflation rate over the year 2017. Ghana Statistical Service estimated 11.8% as the annual inflation rate. The sensitivity estimates of profit in response to either 11.8% changes in input price which expected to reduce profit or 11.8% increase in output price leading to increased estimated profit, estimated using formula below:

$$\left[\frac{Profit}{Total\ cost\ of\ SLMP}\right] \times 100\ or$$
$$\left[\frac{Profit}{Total\ benefit\ of\ SLMP}\right] \times 100$$

3. Results

Table 3 presents findings from the analysis of field data. In terms of the frequencies of farmers using the respective SLMPs, about 42% used animal manure only, while 11% and 5% used compost only and minimum tillage only respectively. Some farmers adopted a combination of the practices i.e. animal manure, compost and minimum tillage. 17% also used animal manure & compost only, 11% used animal manure & minimum tillage only, 3% used compost and minimum tillage only. 11% combined all the three practices studied as shown in Fig. 2.

Table 3. Tools Required for Animal Manure

Tools	Frequency	Percentage
Shovels, wheel barrow, bicycle, sacks, weedicides, head pan	2	1.0
Shovel, wheel barrow, bicycle, sack	30	14.4
Wheelbarrow, bicycle, sack	20	9.6
Bicycle, sacks, head pan	61	29.3
Sacks and head pan	94	45.2
Missing	1	0.5
Total	208	100

Source: Field Survey (December, 2017).

Table 4. Tools Required for Compost

Tools	Frequency	%
Shovels, wheel barrow, bicycle, sacks, pick axe, head pan	36	33.3
Shovel, wheel barrow, bicycle, sack	9	8.3
Wheelbarrow, bicycle, sack	12	11.1
Bicycle, sacks, head pan	6	5.6
Sacks and head pan	45	41.7
Total	108	100

Source: Field Survey (December, 2017).

Also, majority of the respondents were males (93.8%). This is consistent with GSS (2012) that majority of the households are male headed. More than two third of the sample (85%) were married while 24%, 9% and 6% were widowed, single and divorced respectively. About half (52%) of the sample had no formal education. We also found about 40%, 31%, 30% and 1% practiced Traditional, Christianity, Islam and other religions respectively. This has a debilitating effect on manure use since some animals are forbidden by certain religious groups. About 59% of the respondents were Dagaabas and reflect the ethnic groupings in the region, however, lower in Sisaala (22.3%), Waala (15.2%), Lobi (5%) and others (5%) . About 69% of the respondents earn income outside the farm.

The study reveals that, with just sacks and head pans (45%), an individual is good to go with the application of animal manure. It was observed that, some farmers used their bare hands or hoe to help in gathering the manure for application from the dump site. Other farmers indicated that, they sometimes hire wheelbarrow or means of transport to carry manure from the dump site to their farms. Also, 29.3% of the farmers indicated that one needs a bicycle in addition to apply animal manure. The bicycle was meant to facilitate transport of the manure to the farm. The study also found 14.4% of the farmers who indicated a set of tools (shovel, wheel barrow, bicycle and sacks) to enable them farmer apply animal manure on his farm. Table 3 presents frequencies/percentages of respondents' choice of tools for the application of animal manure.

Table 5. Tools Required for Minimum Tillage

Tools	Frequency	Percentage
Bicycle, sacks, weedicides, pickaxe	5	6.4
Knapsack, weedicides	68	87.2
Shovel, knapsack, wheelbarrow, bicycle, sacks, weedicides,	5	6.4
Total	78	100

Source: Field Survey (December, 2017).

Table 6. Estimated Prices of Crop Yields from Survey

Item	Mean Value (GH₵)	Minimum Value(GH₵)	Maximum Value(GH₵)
Price per bag (100kg) maize	97.50	70	120
Price per bag (105kg) sorghum	204.4	160	240
Price per bag (95kg) millet	216.3	180	240
Price per bag(rice)	234.0	220	250
Cost of producing cereals per acre	380.2	6.0	875.0
Dollar to Ghana Cedis ratio	1 Dollar =	GH¢4.6	

Bag=cocoa sack. Source: Field Survey (December) 2017.

Sacks and head pans (41.7%) were required by respondents to apply compost. Other tools mentioned (33.3%) were a set of (shovel, wheel barrow, bicycle, sacks, pick axe and head pan) to ensure complete compost application. However, farmers complained that it is expensive including its transport to cart compost to their farms especially when it was prepared far from the farm. They explained that, the shovel, pick axe and means of transport could be hired or rented from others who trade in them for profit. The acquisition of these tools were found to have been complimented by the Wa East District MoFA staff through a World Bank sponsored project aimed at conserving the soil and water and soil along the tributaries of black Volta river. Accordingly, each participating community have been provided with these sets of tools at a common location accessible to every farmer. Table 4 presents the frequencies/ percentages of tools required for the application of compost.

The tools required for minimum tillage application were largely knapsack sprayer and weedicides (87.2%). The results further indicated that, 6.4% may also needed a set of (bicycle, sacks, weedicides and pick axe) to ensure smooth execution minimum tillage. Their source of knapsack sprayer was either hired, borrowed from a friend or self-purchase. Additionally, 6.4% of farmers indicated (shovel, knapsack, wheel barrow, bicycle, sacks and weedicides) as required for the application of minimum tillage.

Table 6 presents the prices of various cereal crop yields per bag (cocoa sack) over the study period and their relative measurement in kilograms that were used in this study. The prices were collated from respondents based on the prevailing market prices at which their respective products were sold. The estimated means were then used in the following computations. The relative standard measurements (kg) were obtained from MoFA staff as the standard measurements for the yields of the respective crops.

Table 7 presents profitability estimates for the SLMPs under study i.e. animal manure, compost and minimum tillage. The results showed that, animal manure is more profitable to apply comparatively on the field as it yields the highest profit margin. The application of animal manure rewarded the farmer with Ghana cedi {GH¢} 448.2 which is equivalent to $97.4 per acre/season compared to GH¢ 15.3 ($3.3) per acre per season. This is followed by compost application with a margin of GH¢ 327.5 per acre equivalent to $71.2 compared to GH¢15.3 when the farmer is not applying compost

Table 7. Animal Manure, Compost and Minimum Tillage Profitability Estimates

Item	AM (GH₵)	Sensitivity (AM)	Comp (GH₵)	Sensitivity (Comp)	M. tillage (GH₵)	Sensitivity (M. tillage)
Quantity/acre	8.0*		9.5*			
Actual cost of production/acre	380.2 (11.8)	425.1	380.2 (11.8)	425.1	380.2 (11.8)	425.1
Added Cost/acre	31.1 (11.8)	34.8	44.8 (11.8)	50.1	40.7 (11.8)	45.5
Total revenue/acre	867 (11.8)	969.3	701.9 (11.8)	784.7	501.0 (11.8)	560.1
Total revenue without	395.5 (11.8)	442.2	395.5 (11.8)	442.2	395.5 (11.8)	442.2
Total profit with	448.2	407.1 558**	327.5	226.7 366.1**	98.2	86.51 109.89**
Total profit without	15.3	-29.6 62**	15.3	-29.6 62**	15.3	-29.6 62**

AM=animal manure, Comp=compost & M.tillage=minimum tillage, *=maxi bags, **= 11.8 % rise in output value () =Annual inflation rate for 2017. Source: Field Survey (December, 2017).

Table 8. Cost of tools for animal manure, compost preparation and application, minimum tillage

Variable	Sample	Minimum (GH₵)	Mean (GH₵)	Maximum (GH₵)
Cost of equipment for animal manure	208	0.00	449.2	575.00
Cost of tools for compost	108	176.00	467.56	586.00
Cost of equipment for minimum tillage	78	0.00	131.73	457.00

Source: Field Survey (December, 2017).

Minimum tillage was comparatively the least profitable as it gives the lowest profit margin of GH¢ 98.2 or $21.3 per acre per production season compared to GH₵ 15.3 per acre/production season when the farmer is carrying out his normal farming practices.

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4. Discussion

This study sought to elicit the tools required for the application of animal manure, compost and minimum tillage. Smallholder farmers use mostly sacks and head pans to apply animal manure (45%) and compost (41.7%) as shown in Table 4 and Table 5 respectively. Also, about 29.3% of the farmers indicated that one needs a bicycle in addition to apply animal manure. The bicycle was meant to facilitate transport of the manure to the farm. The study also found 14.4% of the farmers who indicated a set of tools (shovel, wheel barrow, bicycle and sacks) to enable the farmers apply animal manure on their farm. Other tools mentioned (33.3%) were a set of (shovel, wheel barrow, bicycle, sacks, pick axe and head pan) to ensure complete application compost. These farmers however largely complained that, it was expensive to transport or cart compost to their farms especially when it was prepared far from the farm. They added that, the shovel, pick axe and means of transport could be hired or rented from others who trade in them for profit. The acquisition of these tools were complimented by the Wa East District MoFA staff through a World Bank sponsored project aimed at conserving the soil and water along the tributaries of Black Volta River.

Knapsack sprayer and weedicides represented 87.2% of respondents who indicated the two were largely required for the application of minimum tillage. The results further indicated that, 6.4% may also need the following set of tools (bicycle, sacks, weedicides and pick axe) to ensure smooth execution minimum tillage. The sources of knapsack sprayers were either hired or borrowed from a friend or self-purchase. Additionally, 6.4% of farmers indicated (shovel, knapsack, wheel barrow, bicycle, sacks and weedicides) are required for the application of minimum tillage. This result affirms that of Grabowski (2011) who revealed that, hoe-cutlass farmers used ox-carts, baskets/head pans and sacks for the application of animal manure and compost. He further indicated that people who do not have ox-carts could still rent their services for the transport of manure to their fields. Similarly, farmers primarily used tridents, hoes and baskets to facilitate manure handling and transportation. Some farmers used even their hands to gather cow-dung in preparation for application on the field (Kim et al., 2011). Farmers who applied minimum tillage do not have to use any new or added tool since no tilling of the land was necessary (Grabowski, 2011).

A survey of market prices for the sets of tools in Table 4, 5 and 6 respectively resulted in a mean cost of GH¢ 449.2 equivalent to $97.7, GH¢ 467.6 equivalent to $101.7 and GH¢ 131.7 which is equivalent to $28.6 for animal manure, compost and minimum tillage applications as shown in Table 8 respectively.

4.1. Profitability Estimates

Generally, the three practices in the study were profitable to apply on the various fields as shown in Table 7. The application of 8 maxi-bags of animal manure rewarded the farmer with GH¢ 448.2 which is equivalent to $97.4 per acre/season compared to GH¢ 15.3 ($3.3) per acre per season when the farmer was not applying animal manure. The study considered the prevailing exchange rate of 1Dollar to GH¢ 4.6. Increasing the number of acres could bring about economy of scale hence increased benefits to the farmer. This result is consistent with that reported in Rwanda where farmers more than double their maize, sorghum and other crop yields after the application of animal manure (Kim et al., 2011). The application of even inorganic fertilizer following past application of animal manure have been reported to have larger yield effects than plots that did not receive past animal manure. The yield response with the inorganic fertilizer necessitates the importance of organic matter in stimulating growth (Njoroge and Zingore, 2019). These yield increases from animal manure application could span over four years (Njoroge and Zingore, 2019; Grabowski, 2011). Similarly, MoFA (2011) reported 680Kg/ acre of maize equivalent to a cash value of GH¢ 302.3 per acre which is close to our observation in this study. The marginal differences may emanate from differences in both soil conditions and agronomic practices in the respective locations. In estimating how sensitive the benefits were to changes in prices over time, the annual inflation rate for 2017 (11.8%) according to GSS (2017) was used. An increase in input price will result in a decrease in benefits from GH¢ 448.2 to 407.1 to the farmer. An increase in output value increases profit margin from GH¢ 448.2 to GH¢ 558.0. A rise in input price usually, results in an increase in output price. The margin in the output price triggered by the rise in input price will determine the value of the benefits holding all other factors constant. Similar findings were reported across the globe upon overview of experimental fields on SLMPs on various soil types that gave 79% average yield increase (Pretty, 2006).

The application of compost resulted in a net profit value of GH¢ 327.5 per acre equivalent to $71.2 compared to GH¢ 15.3 when the farmer is not applying compost as shown in Table 8. The finding shows that compost has the potential of increasing smallholder farmers' food security if properly integrated into smallholder farming activities. This observation was consistent with MoFA (2011) reports which showed 1700Kg per hectare of maize and a net returns of GH¢ 302.3 as estimated from the reports. Net returns of GH¢ 198.57 and GH¢248.5 were also reported among rice farmers without and with fertilizer application respectively (Donkoh and Awuni, 2011). Compost has significantly increased grain yields with benefits ranging between 151 to 351% but variations exist due to differences in ecological conditions (Melaku et al., 2014). Studies in Nigeria has found higher maize yield increases with the application of compost supplements as compared to inorganic fertilizer (Olowoake et al., 2018). A rise in input price by 11.8% leads to a reduction in net benefits from GH¢ 327.5 to GH¢ 226.7 to the farmer. An increase in output price will also increase returns to the farmer, holding all other things constant. A general study of experimental fields across the globe on various soil types reported a 79% yield increases across board (Pretty, 2006).

The analysis of minimum tillage on the farm resulted in net profit value of GH¢ 98.2 per acre which is equivalent to $21.3 as compared to GH¢15.3 when the farmer was not applying minimum tillage as shown in Table 8. Minimum tillage is the least profitable compared to animal manure and compost. This conforms to earlier studies in the upper west region that reported over 50% maize yield increases in successive years with zero/no tillage (Buah et al., 2017). This value was far less than that reported by MoFA (2011) which gives 1700Kg per Hectare of maize and net benefit of GH¢ 302.3 per acre as estimated from the report. Grabowski (2011) revealed that, the benefits of minimum tillage goes beyond yield and can span for over four years. It thus suggests that, accumulating the yearly benefits of GH¢ 98.2 or $21.3 per acre per production season for four years or more years could make significant monetary impact to the smallholder farmer. This benefit from minimum tillage was expected to increase to GH¢109.89 following an 11.8% increase in output price holding all other factors constant. But was equally expected to decline to GH¢86.51 with an11.8% increase in input price holding all other factors constant. This result is in line with FAO (2011) report which commented on yield increases ranging mostly from 10-20% in the initial years. The yield increases could go as high as 100% after 4-5 years of continued application for the ecosystem to adjust. Similarly, yield increases of 50% were recorded in Ghana with the use of minimum tillage (World Bank, 2006). Yield increases could be lower in the initial years depending on other factors such as the exhaustion of the genetic potentials of some of the seeds/crops (Buah et al., 2017). The literature available justifies the need for large scale usage of animal manure, compost and minimum tillage.

5. Conclusion

On the examination of the findings in the context of increasing climate variability and intensifying poverty in the Upper West Region of Ghana, the usage of SLMPs presents hope for smallholder agriculture. Despite the ecological benefits that are accompanying these practices, their application resonates with resource poor smallholder farmers who are unable to afford chemical fertilizers. Above all the positive implications, there is the need to pay close attention to the underlying factors such as labour shortages and declining integration of livestock in smallholder farming systems. Effort therefore to promote SLMPs should assume a broader approach that integrates livestock which is a vital source of manure for household. Policies that seek to improve the system of housing or confinement of livestock will help enhance the quality and availability of manure for use in promoting SLMPs. Also, replication of these practices under different ecological conditions will go a long way to streamline location specific SLMPs for better profit margins. Moreover, there is the need to educate farmers on the appropriate and sustainable agricultural practices. This can be achieved through farmer to farmer knowledge sharing as well as upgrading extension delivery.

List of Abbreviations: CIKOD: Centre for Indigenous Knowledge Organisation and Development. EAs: Extension Areas. GH₵: Ghana Cedi. GSS: Ghana Statistical Service. kg: Kilogram. MoFA: Ministry of Food and Agriculture. NEPAD: New Partnership for African Development. PFAG: Peasant Farmers Association of Ghana. SLMPs: Sustainable Land Management Practices.

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