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GSSP Working Paper # 24

Assessing Crop Production and Input Use Patterns in Ghana – What can we learn from the Ghana Living Standards Survey (GLSS5)?

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Ghana Strategy Support Program (GSSP)
GSSP Working Paper No. 0024

January 2011

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THE GHANA STRATEGY SUPPORT PROGRAM (GSSP)

WORKING PAPERS

ABOUT GSSP

IFPRI's Ghana Strategy Support Program (GSSP) was launched in 2005 to address specific knowledge gaps concerning agricultural and rural development strategy implementation, to improve the data and knowledge base for applied policy analysis, and to strengthen the national capacity for practical applied policy research. The primary objective of the Ghana Strategy Support Program is to build the capabilities of researchers, administrators, policymakers, and members of civil society in Ghana to develop and implement agricultural and rural development strategies. Through collaborative research, communication, and capacity-strengthening activities and with core funding from the U.S. Agency for International Development/Ghana (USAID), GSSP works with its stakeholders to generate information, improve dialogue, and sharpen decisionmaking processes around the formulation and implementation of development strategies.

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1. Introduction

Agriculture in Ghana accounts for about 40 percent of national economy, three quarters of export earnings, and employs 60 percent of the labor force. Agriculture is the backbone of the economy (McKay and Aryeetey, 2004) and the sector has served as the main driver for the growth over the last two decades (World Bank, 2007). Moreover, agriculture is the most important sector for poverty reduction and has helped the country become the first Sub-Saharan African country to achieve the first objective of Millennium Development Goals (MDG1) by halving the country's 1990 poverty rate before the 2015 target year.

However, few studies have documented what the driving forces have been behind the recent agricultural growth and whether such growth can be sustained. Breisinger et al. (2010), among others, provide a rough assessment of the drivers of agricultural growth. According to Breisinger et al. (2010), the crop subsector contributed to 75 – 85 percent of agricultural growth between 1991 and 2006, and within the crop subsector cocoa alone contributed to 15 – 30 percent of total agricultural growth. The rest of crop subsector constitutes a wide range of staple and high value crops, reflecting diversified agricultural production and consumption patterns in Ghana. Growth in staple crop production has primarily been the result of land expansion, together with modest improvement in crop yields. These findings are consistent with those by Bogetic et al., (2007) who emphasize that growth in Ghana has been as a result of land extensification, as well as total factor accumulation. Indeed, FAO data indicates that the rate of land expansion (including land allocated to cocoa production) was four percent per year between 1994 and 2006 (FAO, 2010), while the agricultural GDP annual growth rate was slightly more than five percent during the same period. Obviously, further growth in Ghana's agricultural sector requires more sustainable growth sources other than land expansion. Realizing this, a central component of Ghana's development strategy has emphasized productivity-led and high-value-led agricultural growth as a means to transforming Ghana's agricultural sector in the next 10 to 20 years to help the country achieve middle-income country (MIC) status (National Development Planning Commission, 2005).

Agricultural transformation is characterized as a process of sustainably modernizing agriculture and such a process is often measured by significant improvement in land and labor productivity, greater market-orientation and increased production diversification, as well increased domestic and international competitiveness. To accelerate agricultural transformation it is first necessary to understand the agricultural sector's initial condition. For example, it is crucial to understand current land and labor productivity levels, whether modern inputs have been broadly applied in agricultural production, and the structure of production. The Ministry of Food and Agriculture (MoFA) reports production and area information at the district level on a yearly basis for about 10 staple crops, however, production of many high value crops other than cocoa are not monitored by the country's statistical system. Similarly, the Ghanaian government has recently intensified its promotion of mechanization and fertilizer use for crop production, while there is a lack of systematically collected information assessing the outcome of such policy interventions including crop production patterns and yields, changes in the use of modern inputs, and the employment of labor in production.

The purpose of this study is to fill knowledge gaps in understanding of the current level of agricultural transformation in Ghana. We pay particular attention to the use of

intermediate inputs and modern farming practices drawing on a recent nationally representative household survey. Prior to rushing into an econometric analysis of Ghana's agricultural transformation, it is firstly necessary to conduct a thorough descriptive investigation of the Ghana Living Standards Survey 5 (GLSS5) conducted from 2005 to 2006 to see what we can learn about current levels of agricultural productivity and use of inputs. It is well known that agricultural production activity is not the focus in a typical living standards survey, and thus it is extremely challenging to conduct a comprehensive, agriculturally-focused analysis using the GLSS5 data. However, given the importance of providing a general picture about the level of agricultural transformation in Ghana and the lack of any other comprehensive data source available in the country,[1] we provide a snap-shot assessment of the current agricultural production and transformation situation in Ghana using this data. We specifically focus our analysis on crop production not only because it is the dominant catalyst of Ghana's recent growth (as mentioned previously), but also because so little quality, representative information is available about other agricultural activities, such as livestock and fishery in the GLSS5 (and other sources).

[1] The last time a national, agricultural census was fielded over two decades ago in 1984.

2. Major findings

Before we provide a detailed assessment of the data used for this analysis (Section 3) and of what we learn from GLSS5 in the following sections, we summarize the major findings in this section. Section 4 focuses on the national level assessment of crop production and input use patterns. This national study shows that a majority of rural households grow a wide range of crops and there are more than 20 crops for which more than 10 percent of rural households reported harvesting crops. The assessment of input use in the same section (Section 4) shows that 46 percent of rural households reported hired labor, while, respectively, only 19 percent and 7 percent of households report use of inorganic fertilizer and renting equipment, respectively.

The description of crop production and input use patterns at a spatially disaggregated level is the focus of Section 5. It shows that, while some crops, such as rice, sorghum, millet, and cocoa, have significant spatial patterns, some other crops, including maize, cassava, tomato, are grown by many households in all the four agro-ecological zones. In terms of input use, hired labor carries the highest percentage of households across all the four zones, while the percentage is highest in Forest and South Savannah zones. On the other hand, a strong spatial difference is observed in fertilizer use, as more than 30 percent of North Savannah households use inorganic fertilizer, while the share is 15 percent for the Coast and Forest Zones. Mechanization of agriculture is a policy aimed at agricultural intensification which has a long history in Ghana and has recently been reemphasized by the government. However, number of affirmative responses to mechanization related questions in the GLSS5 is extremely low: for instance, only 392 households (among almost 7,000 households that reported crop production in rural and urban locations) respond yes to questions concerning expenditures for equipment rental. Most households renting equipment are in Forest and North Savannah zones. In North Savannah zone the average land holding size of households using mechanization as a group doubles that of households without mechanization. Households reporting mechanization also appear to be more likely to hire labor, purchase fertilizers and other chemical inputs, which indicates a possible income factor constrain (not necessarily land size) associated with mechanization.

While it is important to assess land and labor productivity and the relationship between land productivity and input use, such assessment is constrained by the data limitations of the GLSS5. After thoroughly investigating the strengths and weaknesses of the data, we decide to use maize as an example for assessing land productivity and the relationship between the productivity and input use in Section 6 for three reasons. First maize is widely grown in the country, by more than 60 percent of rural households according to the GLSS5. Second, a sufficient number of observations are available with output and land harvest information and thus for yield calculation. Finally, the calculated yield using GLSS5 data is close to the statistic number reported by MoFA. However, it is still impossible for our analysis to directly link maize yield with input application because input use is reported at household level instead of the plot and crop level.

Although input use cannot be identified at the crop level, we observe insignificant land productivity differences for maize between households that do and do not use inputs, such as fertilizer, herbicide and purchased seed, on national and agro-ecological zone levels. The only significant different yield gaps are observed in the cases of herbicide use, as well as herbicide use with fertilizer application, the only instances in which maize yield near or reach an average yield of two metric ton per hectare. However, there is not

enough information to help us assess the reasons why there does not exist a strong positive relationship between fertilizer use and maize yield. While better weed control through use of herbicides will improve crop yield, it seems that herbicides are primarily used for land clearance. Thus, it is not clear for us why there is a positive relationship between herbicide use and maize yield. The limitation of the GLSS5 in assessing agricultural productivity further emphasizes the importance for the country to conduct a nationwide agricultural survey, which will make it possible to fully assess the outcome of modern input use, and thus, to provide policy suggestions on how to improve the returns of input use and how to promote their use in agricultural transformation.

We begin our detailed discussion of the abovementioned findings by briefly introducing the agricultural coverage of the GLSS5 in the next section.

3. Agricultural activity data – What does the GLSS5 cover?

The GLSS5 is a multi-topic, nationally and regionally representative household survey that was fielded by Ghana Statistic Service (GSS) over a period of one year from 2005 to 2006. It is the fifth comprehensive household survey implemented by GSS since 1987; such surveys generally aim at providing data concerning household welfare. The survey covers household demographics, income, consumption, agricultural production, migration, and so forth, and has a sample size of 8,687 households. Households in the GLSS5 survey are representative at the regional level for the ten administrative regions (Western, Central, Greater Accra, Volta, Eastern, Ashanti, Brong-Ahafo, Northern, Upper East, and Upper West). Among the 8,687 surveyed households, 5,069 (about 58 percent) are rural households according to their location defined by GSS. The survey is designed also to represent the three agro-ecological zones, i.e., Coast, Forest, and Savannah. For the purpose of this paper, we further define the Savannah into the South Savannah and North Savannah. Table 1 reports the household sample observations by regions and agro-ecological zones.[2]

The agricultural module of the survey is fairly comprehensive. It consists of eight parts, including sections on household landholdings and farm details, equipment ownership, inputs, and crop harvests, amongst others. The section on landholdings provides size of all land that households own or farm on, as well as information about recent transactions or land rights. Information about household expenditures on fertilizer, herbicides, seed purchases, irrigation, hired labor, etc., can be found in the inputs section. In addition, two harvest sections, divided up according to i) staple grains, field, and cash crops vs. ii) root, fruit, vegetable, and other piecemeal crops, provide data concerning which crops were harvested by households, what the quantity was, how much land was used, and so forth. The agricultural information, much like the data for other topics in the GLSS5, is collected via a multiple visits over the course of a month where members are asked to respond based on recall (memory) over a specific period of time. Although recall periods vary depending on the topic, they refer to the last 12 months in nearly all instances in the agricultural module. Using a recall period simplifies the surveying process; however, it does not provide the detailed and accurate data that an agricultural census-type of survey can because an agricultural census also usually includes field visits and crop cutting, in addition to recall information. In particular, relying on the recall method makes it especially difficult to assess information pertaining to roots and other piecemeal crops, which are not harvested at once due to seasonal factors. In addition, the units in which crop production is reported in are not consistent. This, in combination with a lack of questions about area harvested for roots, as well as instances of multi-cropping, makes it impossible for us to precisely discuss the production of certain crops, notably roots like cassava, yam, cocoyam, and potato. While the agricultural module in the GLSS5 provides a wide array of important agricultural topics, the questionnaire on agricultural activities relies on the household, as opposed to the plot and crop levels, as the basic unit of measurement.[3] This, in combination with the choppy sequencing and linking of

[2] Note: the authors (using GLSS5 data) are source of all calculations, tables, and figures, unless noted otherwise.

[3] An additional weakness is worth noting is that in some parts of the module, such as farm details or harvest sections, more than one member of the household can provide a response, while in others, such as

module parts, sections, and questions, makes it difficult to directly connect information across the module. For instance, when a household reports using an input like mechanization or fertilizer, it is not possible to attribute those inputs either to a specific plot and, or crop, both of which are necessary to accurately describe the direct relationship between these factors and production.[4]

Table 1:GLSS5 household sample by regions and agro-ecological zones

	Coast	Forest	South Savannah	North Savannah	Total
Western	345	489	-	-	834
Central	509	180	-	-	689
Greater Accra	1,257	-	-	-	1,257
Volta	270	300	150	-	720
Eastern	195	584	135	-	914
Ashanti	-	1,574	-	-	1,574
Brong-Ahafo	-	420	375	-	795
Northern	-	-	-	795	795
Upper East	-	-	-	600	600
Upper West	-	-	-	509	509
Total	2,576	3,547	660	1,904	8,687

expenditure on input sections, only the main land holder can provide a response. This creates an inherent imbalance in the extent of information available about select aspects of agricultural production.

[4] Although this is not an uncommon weakness for multi-topic livings standards surveys, many of which are principally focused on poverty assessment, it bears mentioning once again because of the limitations it imposes on unambiguously linking driving factors to agricultural and their impacts on welfare.

4. A national level assessment of crop production patterns and input use

4.1 Agricultural landholding

Seventy percent of surveyed rural households reported owning agricultural land, while in the urban areas about one-quarter of households also own agricultural land.[5] The average holding size per household is 4.33 hectare in the rural areas and 2.69 hectare is the urban areas, if we only consider households that own land (table 2, column 4), as opposed to including non-land owners as well (column 2).

Among rural households that do own land, the estimates in table 3 and the kernel density distribution in figure 1 show that nearly half of landholders own less than two hectares, about one third own between two and five hectares, and the remaining 18 percent own more than five hectares. Given that the average holding size of rural households from table 2 is 4.33, this suggests that this 18 percent of households (greater than five hectares) own a disproportionate amount of land. Indeed, as shown in the last column of table 3, this group of households own 64 percent of total agricultural land, meanwhile the other 82 percent of households own 36 percent of total agricultural land.[6]

Table 2: Household agricultural landholding (Ha – hectares)

	Total number of households	Average holding for households (Ha/per household)	Number of households with land	Average holding for households with land (Ha/per household)
Rural	5,069	2.85	3,594	4.33
Urban	3,618	0.68	924	2.69
National	8,687	1.91	4,518	3.96

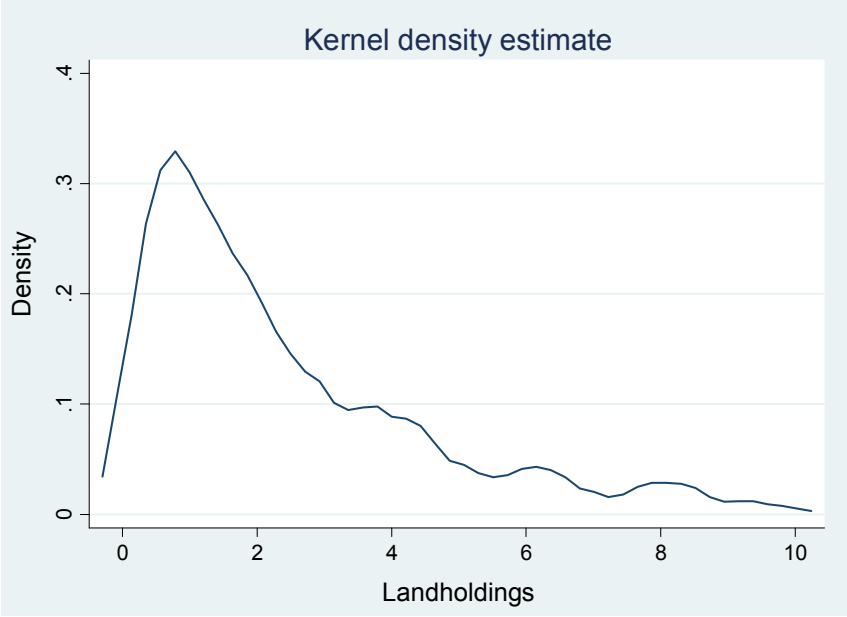
[5] It should be noted that traditional land tenure system still dominates Ghana. When many households answer the question about whether they own a piece of land, they may treat the land they have been cultivated through such traditional land tenure system as the land they owned.

[6] We make a cutoff at 5 hectares because just over 80 percent of the sample reports total household holdings of less than 5 hectares.

Table 3: Number of rural households by landholding size

	Number of rural households that own land	% of total rural households with land	% of total land owned by rural households
Less than 2 Ha	1,803	49	11
2 to 5 Ha	1,201	33	25
5 to 10 Ha	339	11	16
More than 10 Ha	251	7	48
Rural Total	3,594	100	100

Figure 1: Distribution of rural landholding (Ha)



Taking a closer look at distribution of landholding by agro-ecological zone in table 4 below, one can see that the average holding size in the Forest and North Savannah zones, the two largest agricultural zones with 46 and nearly 37 percent of total rural households respectively, is larger than that of the other two zones. Moreover, the North Savannah is the most land abundant zone with an average household holding size of 4.9 hectares, which is 13 percent higher than that of the other three zones. Table 4 also reports average household's family size and number of family labor for the rural households. The average family size is 4.8 persons, of which 50 percent are identified as family labor, which we define as being 15 to 60 years old. In this table we also measure holding size per household member and per household laborer. As shown in table 4, when moving from the Coast to the North Savannah zone, household size and the number of family laborers increase. Larger family size and labor endowments in the

north suggest a greater supply of labor for agricultural production there than in the South. Moreover, the ratio of family members to family laborers is slightly higher in the north than in the south, indicating a high dependency ratio for the north households. However, more land is also available in the North leading to consistently higher land holdings either by per capita or per family laborer ratios in the North than the South. Table 4 also illustrates that per capita holding and land-labor ratios are lowest in the South Savannah, the zone with a the lowest holding to labor ratio.

Table 4: Landholdings by agro-ecological zones (landholding households only)

Region	Number of total landholding rural households	Total landholdings (Ha)	% of total landholding rural households	% of total rural landholdings	Household Size	Number of household family laborers	Household landholdings (Ha/per household)	Per Capita Landholdings (Ha/per household member)	Land-Labor Ratio (Ha/per family labor)
Coast	500	1,830	13.9	11.8	3.9	2.1	3.66	1.2	2.0
Forest	1,354	5,694	37.7	36.6	4.4	2.2	4.21	1.3	2.2
South Savannah	276	1,257	7.7	8.1	5.0	2.4	4.55	1.2	2.4
North Savannah	1,464	7,167	40.7	46.0	6.0	3.0	4.90	1.0	1.9
Rural Total	3,594	15,570	100	100	4.8	2.4	4.33	1.2	2.1

4.2 Patterns of crop production

We now turn our attention to measuring the distribution of household crop production. As shown in table 5, a majority of rural households (83 percent) are involved in crop production in Ghana (about one quarter of urban households also report crop harvests). In total almost 60 percent of surveyed households report crop production and harvest. Comparing with the number of households that own land in table 2, it is illustrated that the number of rural households that report crop harvests (4,350 in table 5) is more than the number of households that report land ownership (3,594, in table 2). On the other hand, the number of urban households that reported crop harvests (859, in table 5) is less than the number of urban households that report land holdings (924, in table 2). It is possible that some rural households farm land owned by other households that is rented or sharecropped (or that reporting errors are present due to a misunderstanding of land ownership questions).

Table 5: Number of households engaged in crop production

	Rural		Urban		Total	
	Number	%	Number	%	Number	%
Reported crop production	4,350	83	859	24	5,209	58
None	719	17	2,759	76	3,478	42
Total	5,069	100	3,618	100	8,687	100

The next question we aim to answer is: What kind of crops do Ghanaian households grow? Quantifying the incidence of crop harvesting is valuable because it helps us understand the potential impact of promoting different crop policies. We address this question by calculating household incidence of crop harvests, as reported in the harvest sections of the agricultural module. The GLSS5 harvest questionnaires account for 43 different crops of which we rank 37 crops from most to least frequent by rural households (and do not consider a few crops that only 1 or 2 households reported producing). Table 6 reports both numbers and frequencies for rural and urban households. As demonstrated in table 6, maize and cassava are the two most dominant crops produced by most rural households (63 and 61 percent, respectively, of total rural households) and quite a lot of urban households (16 and 17 percent, respectively, of total urban households). Obviously many households grow both as the percentage of rural households that grew either maize or cassava is greater than 60 percent.

Table 6: Number of households reporting crop production

	Rural		Urban	
	Number	%	Number	%
Maize	3,291	63.0	565	15.7
Cassava	2,837	61.3	549	16.6
Pepper	2,285	42.5	292	8.3
Plantain	1,813	40.2	400	12.5
Okra	1,773	28.1	203	5.3
Yam	1,770	33.2	256	7.4
Tomato	1,466	27.7	173	4.8
Cocoyam	1,358	29.8	293	9.3
Groundnut	1,254	17.6	106	2.3
Leaf Vegetables	1,060	18.2	127	3.7
Oil Palm	1,023	22.4	175	5.2
Beans & Pulses	1,006	13.7	65	1.5
Millet	986	12.1	69	1.1
Sorghum	980	12.4	45	0.7
Cocoa	848	19.3	128	4.0
Rice	736	8.7	39	0.8
Banana	605	12.4	94	2.7
Pawpaw	598	11.9	88	2.5
Eggplant	594	12.7	115	3.5
Orange	479	10.3	81	2.4
Pineapple	447	9.5	67	1.9
Avocado	337	6.8	66	2.0
Mango	268	5.0	44	1.2
Other Vegetables	268	5.2	46	1.2
Other Staple Crops	231	3.4	31	0.9
Sheanut	180	1.8	1	0.0
Onion	178	3.4	27	0.6
Potato	158	2.1	12	0.3
Coconut	141	3.0	14	0.4
Other Fruits	131	2.6	26	0.9
Cashew	71	1.2	20	0.6
Cotton	67	0.9	1	0.0
Colanut	62	1.1	4	0.1
Sugarcane	39	0.8	13	0.3
Lime/Lemon	29	0.7	1	0.0
Tobacco	29	0.6	0	0.0
Ginger	20	0.4	0	0.0
None	719	17.2	2,759	75.8
Total	5,069	100	3,618	100

The third and fourth most popular crops are pepper and plantain, both common ingredients in Ghanaian cooking. Besides the aforementioned four crops, no single crop is grown by more than 40 percent of rural households, indicating a diverse crop production pattern in the country. There are eight crops grown by more than (or close to) 25 percent of rural households, three of which (including pepper) are vegetables. The other two important vegetables are okra and tomato, which are grown by roughly 28 percent of rural households. This high incidence rate indicates that they are both staples serving to meet household own-consumption and cash crops produced for domestic market. Moreover, both crops are important sources of vitamins and nutrient in the Ghanaian diet. In the case of the tomato, it also serves as a high value crop providing inputs for a variety of processed tomato products.

The remaining two most common crops making up the group of top eight are yam and cocoyam, which are important staples in the Ghanaians diet along with the previously mentioned maize, cassava and plantain. While subsistence patterns of cassava, plantain, yam and cocoyam production can be observed in many places in Ghana (and West Africa), yam has been one of the traditionally traded crops in Ghana and neighboring countries with a long history. According to Smale and Jayne (2009), yam used to be a more popular staple crop than cassava in Ghana, as was the case in some other West African countries. Declines in yam and increases in cassava production have been observed in Ghana and some other West African countries, which is corroborated by the results in table 6. One reason is that yam production is highly labor intensive and has become less profitable with the increase in rural wage rates. The second reason is that improved cassava varieties have boosted yields, while yam yield has remained rather stagnant. In addition, the development of simplified and more efficient cassava processing equipment that is adaptable to a variety of power inputs has tremendously reduced food processing and preparation time for women.

Besides the 8 most popularly grown crops, there are the 13 other crops that are harvested by more than or close to 10 percent of rural households. This group of crops is very diverse, including three important grain crops, millet, sorghum and rice; the country's most important export crop, cocoa; a number of crops serving both as staples and cash crops traded domestically or regionally, such groundnuts, various beans and pulses (grouped), and oil palm; as well as quite a few vegetable and fruit crops, such as banana, pawpaw, orange, pineapple, eggplant, and leaf vegetables as a group. Special attention should be given to this group of crops because some of them have the potential to become increasingly important as nontraditional export or import substitution crops. Indeed, the government has been promoting some of these crops for exports or for import substitution in the recent years. While it is unlikely to obtain enough information to further assess their export and import substitution potential using GLSS5 data, they deserve more in-depth study in the future.

Crops grown by less than 10 percent of households are mainly various vegetables and fruits, as well as a few quite important industrial crops, such as cotton, coffee, sugar and rubber (rubber is not reported in the table because so few households report harvesting it). However, many of these crops are grown by large scale farmers or plantations and, as a result, are unlikely to be fully captured by a national household survey in Ghana. In addition, it should be noted that some tree crops such as sheanut, cashew and colanut are locally important cash crops in some areas. That being said, their popularity at the national level is rather low according to GLSS5 data.

Another question we are interested in is: How many crops, on average, do Ghanaian households grow? To address this question we present table 7 in which the incidence of

crop harvests is considered at household level. As demonstrated in the second to last row of table 7, 14 percent of rural households grow more than 10 crops; an additional 6 percent grow 10 crops. Considering that about 80 percent of rural households report harvesting more than three different crops, it is clear that rural households predominantly diversify their agricultural production across numerous crops, as opposed to specializing in fewer more lucrative options. Given that the majority of rural farmers are smallholders (table 3), it is obvious that for this 80 percent of rural households a diversified crop mix represents a means to reduce the production risks associated with concentrating on a few crops in a subsistence production context.

Table 7: Crop diversification

Number of Crops Harvested	Number of Households	%	Cumulative %
1	154	4	4
2	338	9	13
3	370	9	21
4	445	11	32
5	439	10	43
6	479	11	54
7	472	10	64
8	419	9	73
9	309	7	80
10	278	6	86
More than 10	647	14	100
Rural Total	4,350	100	100

Table 8: Crop specialization

	Rural households with harvested crops		Single crop only		With one other food crop only		With any high value crops only		Remaining	
	Number	%	Number	%	Number	%	Number	%	Number	%
Maize	3,291	76	47	1	13	0	38	1	3,050	70
Roots	3,338	83	44	1	38	1	35	1	3,073	75
Other food crops	3,091	69	10	0	-	-	9	0	3,018	67
High value crops*	3,562	82	38	1	9	0	11	0	3,420	78
Rural Total	4,350	100	154	4	63	2	104	3	3,858	87

*Note: High value crops include vegetables, fruits, cocoa, palm oil, and tree crops (including nuts).

Taking into account the fact that the majority of households in Ghana subsist on a diet primarily consisting of cereals like maize or roots/tubers like cassava as sources of calories (energy), we provide table 8 to further identify any existing patterns between key crop groups. For the purposes of this table, other food crops are defined as rice, beans, pulses, plantains, and bananas, while high value crops are defined as vegetables, fruits, tree and nut crops, cocoa, and oil palm. The table largely confirms the findings from the previous table and emphasizes that when it comes to the specialization of crops, there is no overwhelming pattern or concentration in the type of crops being produced. For instance, we observe that a few rural households report specializing in one or two food crops and grow maize or a root crop with one other food crop. Similarly there are a few households who grew one only food crop together with some high value crops. In other words, we do not see a strong pattern of specialization in the limited number of cases when this occurs.

4.3 Patterns of Input Use

Having provided a succinct overview about land and labor endowments, in addition to crop production patterns, we focus the remaining portion of this section on the use of purchased inputs, such as fertilizer, seeds, hired labor, and mechanization. These inputs are thought comprise an essential component of modern agricultural production and will become an increasingly important component of Ghana's agricultural strategy. First, we focus on the incidence of input use, which is calculated according to expenditures being made for a specific input. It should be noted that there are two exceptions to this method: i) mechanization is assessed both in terms of expenditures on rental equipment and reported mechanization ownership, and ii) credit is identified when households report receiving it, not spending related to credit. In table 9, we can see that nearly two thirds of rural households that report harvest areas also report input expenditures.

The discrepancy between the number of households that report crop harvests and the number that report purchasing input can potentially be explained by the situation where households do not purchase inputs during the survey year. This is feasible because some inputs, especially tools, can be used for numerous years; hence, they are treated as capital in agricultural production functions instead of inputs. However, most other inputs, such as seed, fertilizer or herbicide, including all those listed in table 9 other than owned mechanization, are employed in crop production process as intermediate inputs that cannot be repeatedly employed across multiple agricultural production processes over multiple seasons. As such, for the purposes of this study it is safe to assume that if households do not report expenditures on an input, it can be concluded that the farmers in the household most likely did not use it during the survey year.

Although most inputs have this characteristic in common, different inputs play unique roles in the crop production process. Labor, similar to land, is a necessary primary factor for crop production. Obviously, households provide most of the essential labor inputs throughout the various stages of smallholder crop production. As such, hired labor is mainly a seasonal phenomenon for these households intended to alleviate a bottleneck for certain time-constrained activities. In the case of Ghana, hired labor primarily occurs for land preparation, which involves weeding and plowing (as well as weeding during crop growing season). This is consistent with the findings reported in table 9 showing that 46 percent of rural households report hiring labor in the survey

year.[7] Unfortunately, the GLSS5 does not provide information about when labor was hired and for what purpose.

Table 9: Input use

	Number of rural households	%
Any type of input use	3,289	65
Use of inputs by type:		
Hired Labor	2,306	46
Credit	1,547	32
Agricultural Credit	382	8
Seed Purchased	1,124	22
Inorganic Fertilizer	981	19
Insecticide	797	17
Herbicide	744	17
Rented Equipment	392	7
Organic Fertilizer	341	6
Rented Transport	301	7
Storage	119	3
Irrigation	19	0
Owned Mechanization	12	0

Note: expenditures on hand-tools have been excluded, because they are capital inputs.

In this section, credit, which includes credit for both agricultural and non-agricultural activities, is included when households report receiving it. However, among the 32 percent of rural households that reported receiving credit, it should be highlighted that only 8 percent of them that reported receiving credit for agricultural purposes. Looking into the sources of rural credit in table 10 reveals that borrowing from relatives and friends, followed by traders, are the most common ways for households to obtain credit, as opposed to formal sources.[8] Obtaining credits from traders is the second most important source for agricultural credit in the rural areas. Traders may lend to households who need money to pay for inputs, such as hired labor or fertilizer, prior to harvest in return for their products, e.g., maize or yam. These patterns are consistent for agricultural credit, which is only reported by 7 percent of rural households.

The true intermediate inputs employed in crop production process that are reported in table 9 include seeds, fertilizers (inorganic and organic) and other chemical inputs. In Ghana, it is typical for households to primarily use recycled seeds in maize and other grain production, while it is unlikely for households to require seed purchases for root

[7] Although the GLSS5 input module does elicit information about household expenditures on hand tools, it is not included in this study because they represent a form of agricultural capital, not inputs, that are used by nearly all households regardless of household characteristics, land factors, or crop choice.

[8] Households can report numerous loans and sources.

and tuber production. As such, the finding that 22 percent of rural households report seed expenditures is a fairly sizable number. However, seed purchases may be in greater demand for the production of vegetables, particularly if the crop production is intended for market. Given that the survey does not identify what kind of seeds are purchased by households and that many farmers grew a variety of vegetables, it is reasonable to believe that many seed purchases are not necessary for grain production.

Fertilizer use, if properly applied in sufficient amounts at the appropriate time, in combination with other modern inputs and recommended farming practice, can considerably influence crop yield. In the process of agricultural transformation, increased fertilizer use is a commonly observed phenomenon across countries. In the case of Ghana, GLSS5 reports that 19 percent of rural households purchased inorganic fertilizer in the survey year. It is possible that some households obtained fertilizer through government programs, which would not have been reported as a household fertilizer expenditure. However, as shown in table 11 below, only one percent of rural households that used fertilizer identify MoFA as the only source of fertilizer provision, meanwhile 15 percent these households report MoFA as one of the provision sources. It should point out that the government started to promote fertilizer use in recent years and implemented a fertilizer voucher system in 2008, which continued in 2009 and has potential to do so in 2010. The numbers reported here capture a situation during the survey year, which is expected to be different from the current situation given the government's interventions since.

While the share of households that reported fertilizer use is low, the number of households that reported insecticide and herbicide use is similar (approximately 17 percent of total rural households in table 9) to the number of fertilizer using households. The use of herbicide essentially serves as a substitute for labor devoted to weeding in tropical agro-ecological settings. It is for this reason that we expect to see a substitution relationship between hired labor and herbicide use among households, as well as the positive relationship between land size and use of these two inputs.

Table 10: Type and source of rural household credit

	Any Type of Credit		*Non-Agricultural Credit*		*Agricultural Credit*		*Agricultural Credit for Inputs*	
	Number of rural households	% of rural total	Number of rural households	% of rural total	Number of rural households	% of rural total	Number of rural households	% of rural total
Total	1,547	32	1,209	25	382	7	241	5
Source	number of rural households	% of rural households	number of rural households	% of rural households	number of rural households	% of rural households	number of rural households	% of rural households
State Bank	108	7	69	6	46	11	28	11
Private Bank	78	5	59	5	22	6	10	5
Cooperative	68	4	41	3	34	9	24	9
Government agencies	32	2	18	1	16	4	9	4
NGO	27	1	16	1	11	2	7	3
Business Firm	9	1	6	0	4	1	2	1
Employer	12	1	12	1	0	0	0	0
Money Lender	53	4	46	4	10	3	7	3
Trader	255	16	214	17	53	12	35	14
Farmer	52	3	34	3	22	5	12	4
Relative, Friend, etc.	827	54	672	55	189	53	119	53
Other	120	8	111	10	11	3	5	2
Rural Total	1,547	100	1,209	100	382	100	241	100

Table 11: Sources of inputs

	Any Input		Inorganic Fertilizer		Herbicide		Purchased Seed		Rented Equipment	
Source	Number of total rural households	% of households using any input	Number of total rural households	% of households using inorganic fertilizer	Number of total rural households	% of households using herbicide	Number of total rural households	% of households using purchased seed	Number of total rural households	% of households rented equipment
Private, MoFA & others	18	0	15	1	6	1	6	1	3	1
Private & others	119	3	51	5	38	5	36	3	26	5
Private & MoFA	296	10	120	13	117	14	147	14	46	12
Others & MoFA	8	0	3	0	2	0	3	0	0	0
Private only	2,781	85	777	79	574	78	915	80	382	81
Others only	39	1	7	1	2	0	6	1	1	0
MoFA only	28	1	8	1	5	1	11	1	1	0
Rural Total	3,289	100	981	100	744	100	1,124	100	459	100

We also investigate the sources of inputs reported in the GLSS5. As indicated by Table 11, the vast majority of inputs originate from private sources. This is the case for inputs without specification, as well as some modern inputs such as inorganic fertilizer, herbicide, purchased seed, and rented equipment. That implies that 65 percent of rural households received their inputs almost exclusively from private sources. Approximately 11 to 16 percent of households report MoFA as one of their input sources, while only one percent consider MoFA as the only source of their inputs. This situation is consistent with the fact that the country fully liberalized its domestic input markets during its structural adjustment period in the early 1990s and the government fully withdrew from direct input market activities since then. The recent fertilizer voucher system, which is subsidized by the government, has been designed so that fertilizer is solely provided by the private sector. This suggests that the current input source situation may not differ considerably from what can be observed in the GLSS5 survey.

We also investigate the combination of different inputs and we find that the most common combination is the use of purchased seed with hired labor (15 percent). This is followed by fertilizer with hired labor (13 percent) and herbicide with hired labor (12 percent). As such, table 12 illustrates that the combined use of inputs patterns needed to maximize input complementarities is not the norm in rural Ghana. Instead, we find a situation where key inputs (fertilizer, seed, and herbicide) are commonly bundled with hired labor, but less frequently with each other. This suggests the persistence of labor bottlenecks during production, which are even evident with the use of a potential labor substitute like herbicide. Nonetheless, one can see few instances when non-labor, intermediate inputs are combined to considerably boost productivity.

Table 12: Patterns of combined input use

	Number of rural households	% of total rural households
Fertilizer	981	19
with seed	370	8
with herbicide	234	5
with mechanization	173	3
with hired labor	608	13
Seed	1,124	22
with herbicide	275	6
with mechanization	175	3
with hired labor	688	15
Herbicide	744	17
with mechanization	138	3
with hired labor	567	12
Mechanization	404	7
with hired labor	278	5
Hired labor only	495	10

5. Patterns of crop production and input use across agro-ecological zones

Agro-ecological conditions vary considerably across Ghana, and thus, it is necessary to investigate the patterns of crop production and input use according to different agro-ecological conditions. While GLSS5 survey is designed to be representative at agro-ecological zonal level, without geographic identification at household level, it is unable to conduct a genuine spatial analysis using the survey. Thus, we focus on the aggregate agro-ecological zones for the purposes of providing a sub-national analysis concerning agro-ecological conditions in this section.

Table 13: Number of rural households with harvested crops

	Coast	Forest	South Savannah	North Savannah	Rural Total
Western	111	323	-	-	434
Central	226	132	-	-	358
Greater Accra	67	-	-	-	67
Volta	134	190	105	-	429
Eastern	74	316	71	-	461
Ashanti	-	676	-	-	676
Brong-Ahafo	-	220	220	-	440
Northern	-	-	-	527	527
Upper East	-	-	-	512	512
Upper West	-	-	-	446	446
Rural Total	612	1,857	396	1,485	4,350

In the GSSL5 data, Ghana is classified into three agro-ecological zones: the Coast zone is best characterized as the humid tropics, the Forest zone is known for being more temperate, while the Savannah zone is characterized as more arid grassland.[9] Given significant difference in land holding size and level of income of rural households in the northern and southern parts of savannah zone, we further disaggregate savannah zone into Northern Savannah, which constitutes three north regions of the country, and Southern Savannah, which encompasses the remaining areas of the original savannah zone. Table 13 provides the number of each of the 10 administrative regions' rural households with harvest areas across the four agro-ecological zones. Although a more disaggregate analysis into smaller, more specific agro-ecological zones within each administrative region is merited by the heterogeneity of conditions this information is not

[9] Additional details describing the conditions of each agro-ecological zone, including toposequence, temperature, altitude, temperature, rainfall, humidity, soil quality, growing season, and agricultural potential, amongst others, are not available; however, their inclusion would greatly benefit this analysis.

available in the GLSS5.[10] For this reason, we did not consider administrative regional disaggregation in the zonal level analysis in this section.

5.1 Patterns of crop production across agro-ecological zones

We consider 10 individual crops and 6 crop groups when looking into the crop patterns at the zonal level. Table 14 provides the number of households that reported crop harvest and the percentage of such households by crops or crop groups and across zones. For the purpose of comparison, we also report the same type of information for the national rural households in the first two columns of table 14. As shown in the table, the incidence of which crops were grown by households within each zone varies significantly (as well as nationally). While at the national level maize is the most popular crop, this is only still the case for North Savannah households where 84 percent of households reported crop production. Maize is the second most important crop for the other three zones.

At the national level, cassava is the second most important crop (with 73 percent of total households reporting crop production), while at the zonal level it is the most frequently harvested crop for all zones other than the North Savannah. It should also be pointed out that 89 percent of Coastal, 88 percent of Forest, and 86 percent of South Savannah households engaging in crop production report cassava harvests in this survey. At the national level, 40 percent of crop producing households report yam harvests, which is substantially more popular in the South and North Savannah (70 and 46 percent, respectively). Key grain crops other than maize are mainly grown in North Savannah, as 38 to 63 percent of crop producing households report rice, millet, and sorghum harvests in the zone.

Among cash crops, groundnut is most important in the North Savannah where 74 percent of production households report groundnut harvests, compared to only 22 percent at the national level. Conversely, vegetable production other than tomato harvesting is important for all zones, particularly for the Savannah and Forest zones (excluding the Coast). In the two Savannah zones, 71 and 76 percent of crop producing households report growing vegetables and in the Forest zone the percentage is 65 percent. We focus on tomato production and separate it from other vegetables because of the relatively high percentage of households growing it. At the zonal level, tomato production is important for all four zones, particularly in the two savannah zones where 41 and 36 percent of crop production households report harvesting it. Cocoa is the most important export crop in Ghana and is highly concentrated in the Forest zone: 43 percent of production households report harvesting it in this zone, as compared to only 8 and 6 percent in the Coast and Savannah zones, respectively.

[10] If it were possible to do so, in the interests of a more accuracy and sensitive categorization, the four zones would be disaggregated into the following six categories. The Coast would continue to only be made up of the *Coastal Savannah*, but a distinction would be made in the Forest between the *Semi-Deciduous* and *Rain Forests*. Similarly, the South Savannah would continue to only consist of what is known as the *Transitional Zone*, meanwhile the North Savannah would be divided between the *Guinea* and *Sudan Savannah*.

Table 14: Patterns of crop production by agro-ecological zone

	Rural Total		Coast		Forest		South Savannah		North Savannah	
	Number	%	Number	%	Number	%	Number	%	Number	%
Maize	3,291	76	471	79	1,398	73	286	72	1,136	82
Rice	736	11	-	-	35	2	40	8	661	38
Sorghum	980	14	-	-	-	-	22	5	958	63
Millet	986	14	-	-	-	-	33	10	953	60
Cassava	2,837	73	546	89	1,639	88	340	86	312	27
Yam	1,770	40	121	21	769	39	278	70	602	46
Other Root Crops	1,496	37	128	24	1,125	60	121	30	122	7
Bananas	605	14	59	10	498	25	41	8	7	1
Groundnuts	1,254	22	16	3	79	4	86	20	1,073	74
Other pulses	1,006	17	28	4	84	4	93	27	801	49
Tomato	1,466	34	222	38	559	29	161	41	524	37
Other Vegetables	2,995	66	347	58	1,238	65	276	71	1,134	76
Fruits	2,148	57	332	56	1,561	85	182	47	73	5
Cocoa	848	23	57	8	757	43	33	6	1	0
With harvested crops	4,350	83	612	71	1,857	84	396	83	1,485	92
Without harvested crops	719	17	258	29	288	16	84	17	89	8
Rural Total	5,069	100	870	100	2,145	100	480	100	1,574	100

In table 14 we also observe that most rural households in the North Savannah engage in crop production, as only 8 percent of rural household in this zone do not report crop harvests. On the other hand, 29 percent of rural households in the Coast zone did not report crops harvest, indicating diversified livelihood opportunities in this zone. It is also observed more than one third of crop producing households in the North Savannah zone report harvest for 10 of the 16 crops and crop groups reported in table 14, indicating n especially diverse crop mix pattern in North Savannah. In the other zones, the number of crop or crop groups with more than or close to one third of production households reporting harvests is lower, for instance this number declines to 8 in Forest zone and 5 in Coast zone.

5.2 Patterns of input use across agro-ecological zones

Patterns of input use are also identified across agro-ecological zones and reported in table 15. The data source for table 15 is the same as for table 9, which is drawn from a question about input expenditures (or ownership in the case of mechanization). As shown in table 15, hired labor seems to be more popular in Forest and South Savannah zones in which, respectively, 55 and 57 percent of households reported hired labor. The percentage of households with hired labor falls to 38 percent in the North Savannah and 33 percent in the Coast. While landholding size is consistent larger in the North Savannah than in the other zones (table 4), due to single-season grain production in the north, the percentage of the farmers with hired labor in the North Savannah is actually smaller than in South Savannah and Forest zones (though not in the Coast zone). The average holding size per rural household in the Coast zone is comparable with estimates in the Forest and Cost, but not the North Savannah, where, a much lower percentage of households hired labor. This can be partially explained by the low percentage of households engage in crop production; 71 percent of total zonal rural households engage in crop production in the Coast zone, while in contrast 83 to 92 percent do so in the other three zones. That being said, these differential labor use and hiring patterns are not completely explained by this sole factor and, subsequently, this topic deserves further investigation.

Patterns of intermediate input use, including use of purchased seeds, inorganic fertilizer and other chemical products, also vary across zones (especially for the use of chemical products). The share of households that report inorganic fertilizer use is 31 percent in the North Savannah zone, in contrast with 20 percent in the South Savannah zone and 16 to 15 percent in the two remaining zones. Three factors contribute to the high percentage of fertilizer using households in the North Savannah: 1) crop production is dominated by grains; 2) the percentage of households engaging in crop production is high; and 3) land quality is poor in arid grassland areas (potentially the most influential factor), necessitating more chemical inputs like fertilizer.[11]

[11] While a simple econometric analysis could provide us with a quantitative assessment for these three factors of fertilizer use in the North Savannah, the small number of observations precludes us from a representative investigation of this type.

Table 15: Patterns of input use by agro-ecological zone

	National		Coast		Forest		South Savannah		North Savannah	
	Number of households	%	Number of households	%	Number of households	%	Number of households	%	Number of households	%
Any type of input use	3,289	65	383	49	1,512	69	320	68	1,074	72
Hired Labor	2,306	46	269	33	1,219	55	270	57	548	38
Credit	1,547	32	279	32	775	36	156	33	337	24
Agricultural Credit	382	8	45		174		60		103	
Seed Purchased	1,124	22	132	17	499	23	109	22	384	27
Inorganic Fertilizer	981	19	120	16	353	15	85	20	423	31
Insecticide	797	17	84	11	528	24	52	11	133	9
Herbicide	744	17	76	12	569	25	74	18	25	2
Rented Equipment	392	7	8	1	163	7	19	5	202	12
Organic Fertilizer	341	6	22	4	98	5	13	3	208	13
Rented Transport	301	7	64	9	130	6	84	17	23	2
Storage	119	3	28	4	57	3	17	5	17	2
Irrigation	19	0	6	1	9	0	1	0	3	0
Owned Mechanization	12	0	2	0	1	0	-	-	9	1

The use of herbicide is believed to be substitutable with use of hired labor in weeding. However, at the agro-ecological zone level, one can see that the zones with a high percentage of households using hired labor also have a high percentage of households using herbicide. For example, both the percentages of households using hired labor and herbicide are the highest in South Savannah and Forest Zones (see table 15). On the other hand, an extremely small percentage of households (2 percent) using herbicide in the North Savannah zone indicates less of a demand for herbicide (or a severely inadequate supply). The main purpose of herbicide use in the south of Ghana is for land preparation, during which weeding is a heavily labor-intensive job and herbicide is often used to substitute for labor. Weeding, as a part of land preparation, is relatively less important in the north of Ghana because of arid climate condition, which contrasts with the humid and semi-humid climate condition in the south. Moreover, it seems to be possible that when herbicide is used for land preparation (to clean the land before planting), it requires more labor later for weeding standing crops once they are planted.

Table 16: Rural credit by agro-ecological zone

	Any Type of Credit		Agricultural Credit		Agricultural Credit for Inputs	
	Number of rural households	%	Number of rural households	%	Number of rural households	%
Coast	279	32	45	5	28	3
Forest	775	36	174	8	109	5
South Savannah	156	33	60	12	40	8
North Savannah	337	24	103	8	64	5
Rural Total	1,547	32	382	7	241	5

As mentioned earlier, the use of agricultural credit is not commonly reported by households on the national level, as is also demonstrated in table 16. The South Savannah is the only zone where more than 10 percent of rural, zone households report receiving agricultural credit. We can see that agricultural credit devoted to input use makes up most of agricultural credit; nonetheless, it only ranges from 3 to 8 percent of rural, zone households. These consistently low agricultural credit numbers indicate a lack of agricultural credit availability for rural households. Given the persistence of incomplete markets and information asymmetries in rural areas, it is essential that credit for agricultural purposes be made available to help households overcome information asymmetries and as liquidity or other resource constraints.

At the national level, the number of households using rented equipment or owning agricultural machinery is extremely low in rural areas of Ghana (nationally and across agro-ecological zones). In total, there are only 392 rural households that report equipment rental activity (a rough proxy for the mechanization of agricultural activities) in this survey. Of these households, 163 are in the Forest zone and 202 are in the North Savannah zone. In terms of owning machinery (measured as the ownership of a tractor, plough, trailer, cart, drawn equipment, or sprayer), the number of households amount to only 12 across the entire country, and 9 of them are located in North Savannah. Proportionally, 7 and 13 percent of rural households in Forest and North Savannah zones, respectively, reported the use of rented equipment or owning machinery, as shown in table 15. Observations from a field visit by the authors suggest that rented equipment is mainly in the form of tractors used for the purpose of land preparation. A relatively high percentage) of households renting mechanization in the Forest zone

indicates that land preparation has increasingly become necessary for crop production. This is most likely because more land has become permanent crop land and fallow periods have been significantly shortened. On the other hand, the more modest share (10 percent) of households renting mechanization or owing machines in the North Savannah zone is likely related to the relatively large farming size in this zone.

As a result of the low levels of equipment rental and ownership of machinery, the two proxies are combined to estimate an overall level of mechanization. With this measure in mind, we take a look at the relationship between mechanization, production scale, the use of other inputs, and yield in the Forest and North Savannah zones. In table 17 it is apparent that households applying mechanization, on average, hold larger land endowments and harvest greater quantities of land. Moreover, these households use inputs at a considerably higher rate than households without mechanization. That being said, non-mechanized households in the Forest zone report noticeably larger maize yields. In the North Savannah zone, the same trends are generally observable with respects to average land holdings, land harvested, and input application. However, no difference in maize yields is evident due to mechanization in the North Savannah zone. In the end, it is still hard to assess whether the demand for equipment rental is mainly due to the land size or the alleviation of income constraints, both of which can motivate greater input use and equipment rental.

Given that the use of rental equipment may also relate to other crop production, we also take into account the potential influence of cultivating cocoa in the Forest zone and rice in the North Savannah zone by further disaggregating the households in these two zones according to with or without cocoa or rice in table 18. In the Forest zone, average land size is greater for cocoa farmers than for the farmers without cocoa, and the size is the greatest for the cocoa farmers renting equipment. While cocoa farmers have larger harvest areas than non-cocoa farmers, the average size of harvested maize areas is less different between these two groups of farmers. In terms of maize, non-cocoa farmers have higher yields than cocoa farmers, while there is no difference in yields between households that rented equipment and those that did not in each group. However, the households that rented equipment, regardless of whether cocoa is grown, on average hired more labor and purchased more fertilizer and other chemical inputs. It is still not clear what the main factors are that cause such input use patterns, which seems to be unrelated to maize production and yield, as well as whether cocoa is grown.

In the North Savannah, the zone where much of Ghana's rice production is concentrated, rice does not appear to be the prime factor explaining the level of mechanization presented in table 19, which seems to be more closely related to the landholding size and harvested areas (but not necessary the harvested maize areas). Again, regardless of rice production, the households that use rental equipment tend to hire more labor and other purchased inputs (despite not necessarily reporting higher maize yields). The same reason used to explain the increased use of hired labor when more herbicide is used for land preparation can explain this phenomenon too, i.e., labor becomes complementary when large size of land is plowed by machine given that land is not a constraint in many places in the north. In sum, one can consistently see that mechanization is associated with average larger land size and higher levels of input use in both of these zones, however, it cannot be associated with higher maize yields or other consistently defining patterns.

Table 17: Mechanization in the Forest and North Savannah zones

	Forest		North Savannah	
	Mechanization Users	*No Mechanization*	*Mechanization Users*	*No Mechanization*
Number of Households	164	1,693	211	1,363
Average Household Size	4.34	4.35	6.02	6.01
Total Land Owned	860	4,787	2,043	5,104
Total Harvest Area	218	1,747	1,449	3,947
Avg. Landholding	5.25	2.83	9.73	4.00
Avg. Harvested Area	1.33	1.03	6.90	3.10
% of Households Hiring Labor	85%	62%	53%	39%
% of Households Purchasing Seeds	40%	25%	47%	27%
% of Households Purchasing Herbicide	44%	21%	62%	42%
% of Households Purchasing Fertilizer	44%	21%	62%	42%
% of Households Purchasing Inorganic Fertilizer	39%	16%	52%	30%

Table 18: Mechanization and cocoa in the Forest zone

	With Cocoa		Without Cocoa	
	Mechanization Users	*No Mechanization*	*Mechanization Users*	*No Mechanization*
Number of Households	92	665	72	1,028
Avg. Household Size	4.34	4.60	4.33	4.18
Total Land Owned	702	3,055	111	1,628
Total Harvest Area	172	1,241	35	457
Avg. Landholding	7.63	4.59	1.55	1.58
Avg. Harvested Area	1.87	1.87	0.49	0.44
% of Households Hiring Labor	80%	64%	93%	61%
% of Households Purchasing Seeds	36%	21%	46%	28%
% of Households Purchasing Herbicide	53%	30%	31%	14%
% of Households Purchasing Fertilizer	53%	30%	31%	14%
% of Households Purchasing Inorganic Fertilizer	44%	20%	31%	13%
Total Harvested Maize Area	40	191	33	416
Avg. Harvested Maize Area	0.43	0.29	0.46	0.40
Avg. Maize Yield	0.79	0.69	1.26	1.71

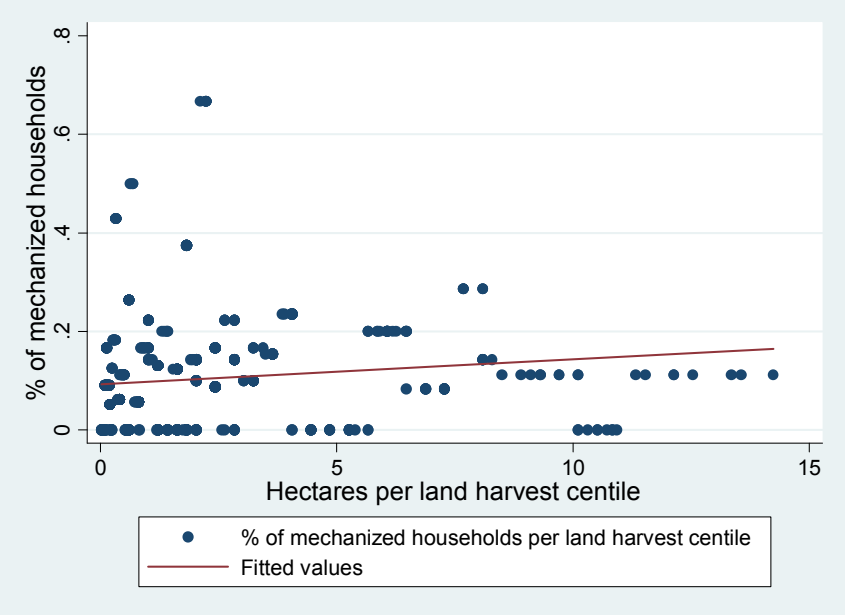
Table 19: Mechanization and rice in the North Savannah zone

	With Rice		Without Rice	
	Mechanization Users	*No Mechanization*	*Mechanization Users*	*No Mechanization*
Number of Households	112	452	98	823
Total Land Owned	1,726	1,792	481	3,307
Total Harvest Area	801	2,597	655	1,724
Avg. Landholding	15.41	3.96	4.91	4.02
Avg. Harvested Area	7.15	5.75	6.68	2.10
Avg. Household Size	5.67	6.21	6.69	5.94
% of Households Hiring Labor	51%	36%	55%	40%
% of Households Purchasing Seeds	54%	30%	41%	26%
% of Households Purchasing Herbicide	61%	45%	63%	41%
% of Households Purchasing Fertilizer	61%	45%	63%	41%
% of Households Purchasing Inorganic Fertilizer	54%	35%	51%	28%
Total Harvested Maize Area	112	414	101	429
Avg. Harvested Maize Area	1.00	0.92	1.03	0.52
Avg. Maize Yield	0.83	1.01	0.80	0.66

Figures 2 and 3 further confirm the finding that there is a positive relationship between household mechanization and greater average land use in the Forest and North Savannah zones, respectively. The following kernel densities plot the percentage of households applying mechanization (Y-axis) per land area harvested centiles (X-axis). In both cases, which have been censored for outliers at the right tails of the distribution, it is clearly shown that households with larger reported harvest areas use mechanization at higher rates. Although not presented here, the same can be said for kernel densities with land holding centiles (as opposed to land harvested centiles).

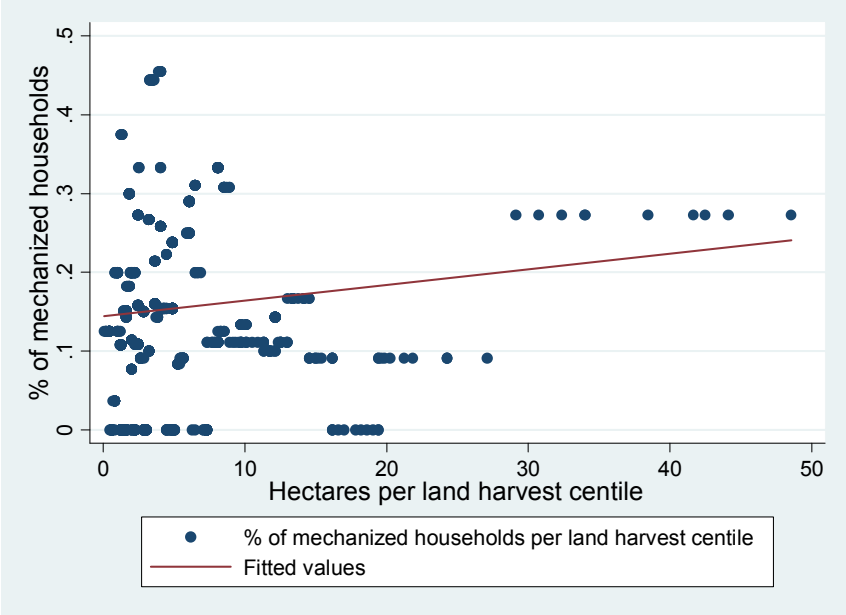
Thus, it is apparent that although the application of mechanization in Ghana remains low across the board, it is considerably higher in the Forest and North Savannah zones. In those agro-ecological areas, it can be shown that production of key crops, cocoa and rice (respectively), have little to no effect on mechanization use. Moreover, in both cases, mechanization appears to be related to larger average household land holdings and harvest areas, as well as greater use of complimentary inputs. Nonetheless, neither direct nor indirect efforts to boost productivity are apparent in maize production in either case.

Figure 2: Forest Zone households applying mechanization by land harvested (Ha) centiles



Note: Forest zone covers roughly half of Brong-Ahafo.

Figure 3: North Savannah zone households applying mechanization by land harvested centiles



6. Land productivity - the case of maize

The most important indicator of agricultural transformation is significant improvement in agricultural productivity. While the assessment of current land productivity is extremely important for Ghana, as indicated in Section 2, it is impossible to accomplish this for most crops in this study due to the data limitations. Consequently, we decided to focus on maize for such an assessment in this section, given that, as noted in sections 4 and 5, maize is a widely grown crop by most rural households across zones and because it is one of the only crops with sufficient reported information in the GLSS5. Even in this case, the study of land productivity suffers from additional data weakness that limits the sample size of eligible maize harvesting observations. In particular, information concerning the amount of harvested, unit measure of output, and land used by crops is not available for all households that reported maize production. If any of these components was not reported by a maize-growing household, this household is not included in the productivity assessment here because an accurate yield cannot be calculated.

In addition, trustworthy unit conversions (to a uniform unit, e.g., metric ton) are not available for many reported units of production. In the survey households reported the unit measures in various forms including American tin, basket, bowl, bunch, bundle, margarine tin, maxi bag, mini bag, and many others. Neither GSS nor MoFA provided a comprehensive list of unit conversions, making it difficult to include all observations in maize yield estimation. It should be noted that this is a universal issue for all crops in the data and not just for maize. In the case of maize, fortunately, the vast majority of households reported fairly standard units like maxi and mini bags, which simplifies unit conversions and allows us to include upwards of 98 percent of potential maize observations.[12] Based on an incomplete list of unit conversions received from MoFA, maize yields are estimated for the households with full information discussed above. The leaves 2,035 households, which represents a sample size reduction of roughly one third from the number of rural households that reported maize harvests (3,291).

Table 20 reports the distribution of these 2,035 household observations across zones, zonal aggregation of harvest maize areas, as well as levels of total and maize harvest areas. There we can see that the majority of maize producing households are located in the Forest and North Savannah, and that these two zones account for over 80 percent of total area harvested for maize. Interestingly, the average number of hectares for maize production in the Forest and South Savannah zone is considerably smaller than in the Coast and North Savannah zones. Subsequently, one can see that although the greatest total numbers of hectares of maize are cultivated in the North Savannah, these only account for about 22 percent of total harvest areas in that zone. On the other hand,

[12] Given these data and unit conversion limitations, the following is a summary of the units accounted for when calculating maize yields, as well as a few other key crops that are analyzed here within. 1) Maize: mini bags, maxi bags, bowls, American tins, and margarine tins. In total, these account for 98 percent of reported maize harvest, unit observations. 2) Groundnuts: mini bags, maxi bags, bowls, American tins, and margarine tins. In total, these account for 99 percent of reported groundnut harvest, unit observations. 3) Sorghum: mini bags, maxi bags, and bowls. These account for 99 percent of reported sorghum harvest, unit observations. 4) Rice: mini bags, maxi bags, bowls, and American tins. In total, these account for 99 percent of rice harvest, unit observations. Although these data and unit conversion limitations are in issue, the extremely high percent of harvest, unit observations accounted for suggests that there are not considerably omissions in our yield estimates.

maize harvest areas account for approximately 41 to 46 percent of total harvest areas in the Forest and South Savannah zones, followed by the Coast where maize harvest areas represents more than two thirds of total harvested hectares.

Next, table 21 presents maize yields reported by agro-ecological zone and compares them to estimations provided by MoFA. The estimated maize yield using GLSS5 data at the national level is 1.27 ton per hectare (mt/ha), about 20 percent below the average, national yield reported by MoFA from 2002 to 2005. At the agro-ecological zone level, the level of yield calculated with the GLSS5 data is very close to the yield reported by MoFA for the three southern most zones. As such, the yield estimate discrepancy at the national level can be clearly attributed to a significant yield gap in the North Savannah zone, which accounts for 40 percent of qualified observations. Both, in our estimation and in MoFA's calculation, the North Savannah has the lowest maize yield. However, the yield gap between the north and south is much larger in the GLSS5 data. Considering that the north has the largest number of qualified observations (797) and that most northern households have only one maize season (which implies relatively easy recall for farmers) we conclude that this gap is not as a result of lower data quality in the north (two maize seasons are more common in the south of Ghana). The discrepancy between these estimates needs to be further investigated in the future.

It is generally thought that the low land productivity in crop production, particularly in maize production, is due to insufficient fertilizer use. In order to address this, the government of Ghana has promoted fertilizer use through various programs, the most important of which is the introduction of a fertilizer voucher system in the last few years. Thus, the relationship between maize yield and fertilizer use is crucial for understanding agricultural productivity in rural Ghana. In order to get at this issue we first assess how many qualified maize households reported fertilizer use (via expenditures), which is reported in table 22. Again, as previously mentioned, fertilizer use cannot be directly linked to specific crops due to the structure of the survey. Given that number of qualified maize households are lower than the total observations of maize growers, only 501 qualified maize households reporting inorganic fertilizer. This is because some observations that report growing maize and use fertilizer but do not report consistent information concerning production making it difficult to estimate maize yields. Considering this limitation, we only take into account crop producing rural households (i.e., we exclude those households without crop harvest). As such, we find that the percentage of households reporting use of inorganic fertilizer as a share of national total maize producing households in table 20 is nearly 25 percent, which is very similar to the percentage of households as a share of national crop (not only maize) producing households in table 15 (19 percent). The lack of a considerable difference in this comparison suggests that fertilizer is indeed mainly used for maize production.

Table 20: Maize producers by agro-ecological zones

	Maize producers		Harvested maize area		Harvested area for all crops (Ha/per HH)	Harvested maize area (Ha/ per HH)	Maize in total harvested areas (%)
	Number	% in total	Ha	% in total			
Coast	203	10.0	276	12.7	2.01	1.36	67.7
Forest	773	38.0	703	32.2	2.20	0.91	41.4
South Savannah	262	12.9	185	8.5	1.53	0.71	46.3
North Savannah	797	39.2	1,134	52.0	6.61	1.42	21.5
Rural Total	2,035	100	2,182	100	3.20	1.07	33.5

Table 21:Maize yield by agro-ecological zone

	Number of qualified households	Yield (ton/ha)	Yield reported by MOFA (ton/ha)*
Coast	203	1.64	1.69
Forest	773	1.35	1.48
South Savannah	262	1.48	1.44
North Savannah	797	0.83	1.16
Rural Total	2,035	1.27	1.56

* 2002-05 average, calculated from the data provided by MoFA (2007)

However, when we look at the number of households by agro-ecological zone in table 22, we realize that the numbers are quite different from the corresponding numbers in table 15 (where all crop households are included). For example, when only considering the qualified maize producing observations in table 22, one can see that only 28 qualifying households reported use of inorganic fertilizer in the Coast zone. This is in comparison to the results in table 15 where the number of households reporting fertilizer use (for any crop) in the Coast is 120. The difference between tables 22 and 15 is roughly a magnitude of 3.3. The discrepancy between these two types of calculations is less considerable in the other three zones. For example, the difference is reduced to 1.3 times in the Forest zone (and roughly 40 to 60 percent for the two Savannah zones). This indicates that, at the agro-ecological level, households that reported fertilizer use are more likely to use fertilizer for maize production in the three zones other than in Coast, while in the Coast zone a significant number of households that reported fertilizer use apply them for crops other than maize. Given that Accra, the capitol and largest city in Ghana, is located in the Coast zone, it is possible some of these households in peri-urban areas near the city apply fertilizer for the production of high value crops intended for urban consumers (e.g., vegetables) or exports (e.g., some tropic fruits). This speculation is further supported by comparing the percentage of households using fertilizer across these two tables. It shows that in both tables 22 and 15 the percentages are very similar in the three zones other than the Coast, meanwhile the percentage in the Coast zone is 13.8 percent in table 22 and about 16 percent in table 15 in the Coast zone. One additional observation from table 22 is that the highest percentage of fertilizer use is for maize households in the north (nearly 33 percent), which is consistent with the pattern for all production households in table 15.

Table 22: Maize households and fertilizer use by agro-ecological zone

	Number of qualified households	Households using fertilizer		Households using inorganic fertilizer	
	Number	Number	%	Number	%
Coast	203	31	15.3	28	13.8
Forest	773	179	23.2	153	19.8
South Savannah	262	65	24.8	60	22.9
North Savannah	797	355	44.5	260	32.6
Rural Total	2,035	630	31.0	501	24.6

We now turn to assess the relationship between fertilizer use and maize yield. Given that we cannot identify the application of fertilizer at the crop level, we calculate the maize yield for two groups of households: i) a group in which all households reported use of fertilizer and ii) another group of households without any reported fertilizer use. Again, we only consider the qualified maize growers with sufficient production information in table 23. There, we can see the first important finding is that the average maize yield for the group of households with fertilizer is not necessarily higher than the yield for the group of households without fertilizer use.

In the Coast and Forest zones, the yield for the first group of households is actually lower than the yield for the second group. Only in the South Savannah zone, do we see a more intuitive, positive relationship between fertilizer use and maize yield: the average yield for the group with fertilizer use is higher than that for the group without fertilizer use. Moreover, the yield for the group with inorganic fertilizer is the highest. While in the

North Savannah, yields for fertilizer households are higher than that those for non-fertilizer households, yet the yield difference between the two groups is modest and level of yield is low in both cases. Given that there are few qualified fertilizer households in the Coast zone, measurement error for a subset of this small sample could potentially affect the estimation results for the entire group. While the number of observation in the Forest zone is modestly high for the group with fertilizer use (179), the yield difference between the two groups of households is insignificant. Such mixed outcomes of yield estimations reported in table 23 only allow us to a general conclusion: fertilizer use did not result in impressive overall yield improvement in maize production. While this is an important finding, the reasons driving this outcome deserve more in-depth study, which unfortunately goes beyond what we can learn from the GLSS5 data.

Table 23: Household maize yield and fertilizer use by agro-ecological zone

	Qualified maize households		Maize households using fertilizer		Maize households using inorganic fertilizer		Maize households without use of fertilizer	
	Number of households	Maize yield (ton/ha)	Number of households	Maize yield (ton/ha)	Number of households	Maize yield (ton/ha)	Number of households	Maize yield (ton/ha)
Coast	203	1.64	31	0.47	28	0.51	172	1.85
Forest	773	1.35	179	1.12	153	1.21	594	1.42
S. Savannah	262	1.48	65	1.56	60	1.61	197	1.45
N. Savannah	797	0.83	355	0.95	260	0.9	442	0.72
Rural Total	2,035	1.27	630	1.06	501	1.09	1,405	1.36

We also assess the relationship between use of other intermediate inputs and maize yield, given that the unexpected relationship between fertilizer and maize yield may be the result of a lack of a combined modern input use. Table 24 considers herbicide, purchased seeds, as well as the combination of fertilizer and purchased seeds. In the case of herbicide use, we only consider the Coast and Forest zones, few households in the two Savannah zones reported use of herbicide. Both in the Forest zone and for the country as a whole, the average yield for the group of households with herbicide use almost doubles the yield reported for the other group of households without it. This is not only the largest difference in maize yield associated with the use of a modern input, but also the first time we find a yield near two mt/ha for a sufficiently sized sample of observations. However, it is unclear why herbicide leads to such a large difference in yield. In the Coast zone, on the other hand, we do not find a similar result, though the small number of households precludes us from making any clear conclusions.

In table 24 we can also see that the story related to seed purchases is quite mixed in the two zones where a sufficient number of observations report seed purchases in order to facilitate a comparison (Forest and North Savannah zones). In the Forest zone, average yield for the household group with seed purchases is lower than that for the counterpart group, while for the North Savannah zone, the reverse pattern is present. For the country as a whole, the yield for the group reporting seed purchases is slightly lower than that for the second group. In all cases, however, the difference is modest, which suggests that using purchased seed seems to only have a limited effect on influencing maize yields.

Table 24:Input use and maize yield by select agro-ecological zone

	Number of maize households using input	Yield, average from those households using inputs	Number of maize households without inputs	Yield, average from those households without inputs
Herbicide				
Coast	39	1.26	164	1.76
Forest	284	1.97	489	1.00
Rural Total	388	2.05	1,647	1.02
Purchased Seed				
Coast	35	0.59	168	1.85
Forest	250	1.18	523	1.42
South Savannah	78	1.83	184	1.35
North Savannah	179	1.05	618	0.76
Rural Total	542	1.20	1,493	1.30
Fertilizer and Purchased Seed				
Coast	14	0.23	151	1.99
Forest	80	1.30	424	1.53
South Savannah	24	1.09	143	1.19
North Savannah	104	1.24	367	0.71
Rural Total	222	1.15	1,085	1.40
Fertilizer and Herbicide				
Forest	69	1.64	405	1.03
Rural Total	388	2.05	1,647	1.02

When fertilizer use is combined with purchased seed, we find a total of 222 observations for the country as a whole in Ghana, which is considerably less than the 630 qualifying fertilizer and 542 qualifying purchased seed household found when assessing individual input use. The smaller number of observations requires us to explain results with caution. In table 24 we only see a significant yield gap in North Savannah between households applying this combination of inputs and households that do not. It should also be noted that this is first time that we observe a maize yield in North Savannah that is close to the national average of 1.27 mt/ha. In terms of fertilizer and herbicide use, we see that the number of households is also proportionally quite small in the Forest zone and across the rural total. That being said, a productivity gap positively associated with using these two inputs in combination is clearly evident in the Forest zone and nationally. These results suggest, amongst other points, that promoting herbicide application, as well as combined herbicide and fertilizer use, may be an effective way to increasing maize productivity.

In conclusion, there is insufficient information in GLSS5 to allow us to better assess the current situation of agricultural productivity and its relationship with the use of modern input. While the only crop that allows us to estimate the yield is maize, once we associate maize yield with input use, the results are very mixed. Although input use cannot be identified at plot and crop level, the insignificant difference between the two groups of households categorized by the input use indicates that in most cases, these

inputs, including fertilizer, herbicide and purchased seeds, did not significantly improve the land productivity in maize production. The only considerably different yield gaps of note are observed in the cases of herbicide use and combined herbicide application along with fertilizer use; these are the only instances with a critical mass of observations where maize yields are close to or reach the level of two mt/ha. However, there is not enough information to help us assess the reasons for a lack of a stronger positive relationship between fertilizer use and maize yield (or the existing positive relationship between herbicide use and maize yield). This limitation of the GLSS5 data further emphasizes the importance of regularly conducting national surveys focused on agriculture. Such a resource will make it possible to fully assess the outcome of modern input use and, thus, provide policy suggestions on i) how to improve the returns to input use and ii) how to appropriately promote their use as part of an agricultural transformation process and rural development strategy.

7. Further research questions

It is clear that additional questions concerning the impacts of inputs on agricultural production need to be answered in order to realistically assess the potential of Ghana's agricultural transformation. A number or key research questions come to mind, such as:

- What is the relationship between rural labor constraints and herbicide use?
- What is the relationship between rural labor constraints and mechanization?
- What are the reasons behind ineffective, inefficient, and varying fertilizer use? Can they be explained by insufficient quantity or inadequate quality?
- On the other hand, are responses to fertilizer being driven by specific conditions that cannot be tested with this data, such as soil quality and rainfall?
- Would productivity increase if fertilizer use were to be promoted along with technical farming training and a suitable mix of other productivity enhancing field inputs?
- Would it be effective and efficient, for instance, to broadly promote fertilizer use coupled with infrastructure investments, agricultural credit subsidization, and a mechanization intervention?
- What roles do the public and private sectors play in the distribution of inputs? Who does herbicide, a private sector input, appear to boost productivity more so than fertilizer, an input supported by public sector interventions?
- What is the current role of purchased seeds in Ghanaian agriculture? Do they have a role to play in agricultural modernization?
- What are the key constraints to Ghana's proposed agricultural modernization (labor, other inputs, mechanical power, specialized equipment, climate changes, market access, etc)?

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