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Original Research

ASSESSMENT OF MECHANIZATION STATUS FOR SOME MAJOR CROP VALUE CHAINS IN GHANA

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Abstract

Mechanization of agriculture is widely accepted as a means to raise agricultural output and ensure sufficient food supplies. Previous failed attempts to mechanize Ghana's agriculture have been linked to a failure on the part of policymakers to recognize the unique mechanization needs of major value chains and staple crops. The study assessed the status of mechanization for some major crop value chains in Ghana to provide useful recommendations to sustainably improve the level of mechanization. The study gathered mechanization and production data on six crop commodity value chains, including maize, rice, cassava, tomato, cowpea, and groundnut, from all 16 regions of the country. Pre-production, production, post-harvest/storage, processing, and marketing for six (6) major staple crops, namely maize, rice, cassava, tomato, groundnut, and cowpea, were identified as relevant value chains across Ghana's 16 administrative regions. Levels of mechanization ranged from 21.3% in the Volta area for rice to 2.5% in the Western North and Western regions for cassava. Rice had the highest amount of mechanization across all regions, whereas cassava had the lowest. According to the findings, manual labor accounts for more than 78 % of all farm operations under the most optimistic scenario. It should not come as a surprise, then, that young people are turning away from the agricultural industry, leaving it to be dominated by the elderly population. Investing in the development of indigenous competency in demand-driven agricultural technology is a much sustainable strategy for elevating agricultural mechanization and modernizing agriculture in Ghana. It is suggested that legislation be drafted to implement these approaches across all levels of education in the country.

Keywords: Mechanization, Ghana, Agriculture, Value Chain, Commodity, Policy

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1.0 INTRODUCTION

Agriculture constitutes an important sector in Africa's economy, providing employment and food security to the inhabitants. It contributes 32% of Africa continent's gross domestic product (GDP) and its potential market size is expected to increase up to 1 billion dollars by 2030 according to World Bank (2019). However, productivity is low to meet the emerging market and increasing population. Moreover, Africa has over a million hectares of undeveloped farmlands, representing about 60% of the world's undeveloped farmland (World Bank, 2019). Despite its resources in terms of underdeveloped farmlands and human capital, Africa has the lowest land productivity in the world, both in terms of crop and livestock production. About 60% of agriculture is undertaken by human power characterized by small-holdings. Most agriculture production activities are mostly undertaken by women, the elderly and children. This disturbing situation is different from other developing and emerging countries in Asia and Latin America (FAO, 2014).

Agricultural mechanization has been recognized to improve agricultural productivity and food security. To achieve optimum yields, meet the timeline of pre-harvest activities such as land preparation, planting, weeding, fertilizer and pesticide application, harvesting and post-harvest activities like sorting, grading, drying, and processing mechanization plays a critical role. The application of mechanization in agriculture production activities provides opportunities for both on-farm and non-farm sectors through job creation and sustainable income. Commercial and intense production that can lead to higher productivity can be realized through mechanization.

The implementation of the various development strategies saw some improvement in the targeted revitalization of agricultural mechanization in Ghana. The inability of the major policies targeting mechanization to achieve full impact stems in part from the fact that it is always captured as a sub-component in these policies. But agricultural mechanization is a much broader sector that encompasses other disciplines along the agricultural value chain. The implementation of the strategies aimed at propelling the agricultural mechanization sector is always constrained by treating the sector as a subsidiary. Policy documents targeting only agricultural mechanization on a national basis are almost nonexistent and therefore indicate the low priority placed on the sector. Policy implementation strategies have not highlighted appropriately, the importance of the development of agricultural mechanization networks in the country and the sub-region. This situation necessitated the need to mechanize agriculture in Africa, and Ghana, particularly as part of the agenda to achieve socio-economic development across the continent.

Assessment of mechanization status for major crops value chains is needed to provide information on the mechanization adoption levels. Such information is required to help guide mechanization support services and interventions for sustainable impact within the agricultural value chain. Furthermore, such information could help to re-align existing agricultural mechanization policies, such as Food and Agriculture Sector Development Policy (FASDEP II) to suit current trends for greater impact.

The aim of this study is to assess the mechanization status of some major crop value chains in Ghana. The following objectives are to be achieved by the study.

i. Identify existing relevant crop value chains.
ii. Assess the levels of mechanization for the identified crop value chains.
iii. Propose recommendations to promote the adoption of appropriate mechanization technologies.

2.0 METHODOLOGY

Study area and crop commodities

Ghana is located in West Africa, bothered in the north and northwest by Burkina Faso, to the east by Togo, to the west by Côte d'Ivoire and to the south by the Gulf of Guinea. The country is divided into 16 administrative regions with 254 metropolitans, municipal and district assemblies (MMDA). The country has predominately undulating terrain with less than 1% slopes. The major drainage in the country is the Volta River basin and the artificially created Lake Volta. The country is distinctively categorized into five main agroecology zones based on climate and natural vegetation. They are the rain forest, deciduous forest, transition, coastal savanna and the savanna (which includes the Guinea and Sudan Savanna).

The study collected mechanization and production data on 6 crop commodity value chains across all 16 regions of the country. The crop commodities were maize, rice, cassava, tomato, cowpea and groundnut. Maize is the most important cereal crop in Ghana. The crop is predominantly grown in small-holder farming systems under rainfed conditions with limited inputs. Maize is grown by the majority of the rural population because of its ability to fit into different farming systems and its great potential for increasing yield under improved management practices compared with other grain crops. It is increasingly becoming an important component of poultry feed in the livestock feed sector and to a lesser extent, the brewing industry. Maize is cultivated in almost all the regions across the country. It is processed into varying dishes among the different ethnic groups and forms the highest source of carbohydrates in Ghana and is considered a food security crop. Rice is the second most important cereal in Ghana in terms of consumption. Rice consumption keeps increasing owing to population growth, urbanization and changes in consumer habits. It is increasingly replacing other traditional staples of both rural and urban dwellers and it is grown in most communities in Ghana. Recently, Ghana's rice sector has attracted the attention of stakeholders and policymakers largely due to the increase in consumption and the effect of rising import bills on the economy. Ghana depends largely on imported rice to make up for the deficit in domestic supply, irrespective of numerous government interventions over the years.

Cassava is considered a food security crop in Ghana because of its ability to withstand drought and several plant pests and diseases. Some of the key characteristics of the crop include high carbohydrate content, drought tolerance, its ability to perform under marginal soils and flexibility in relation to its planting and harvesting time. Tomato is an important component of every Ghanaian meal, and its cultivation contributes significantly to livelihood improvement. It is one of the vegetables that contribute immensely to the socio-economic development of the country. The deficit in fresh tomato supply is annually catered for through importation from neighboring Burkina Faso, especially during the off-season. The crop's production system is characterized as rain-fed and irrigated. Whereas the rain-fed system can be seen increasing across the country, the irrigated production is centered around areas with large government irrigation schemes, most of which are found in the northern regions of the country with a few in the Ashanti and Greater Accra regions. The seemingly low irrigation facilities are a constraint to off-season tomato

production and therefore contribute to the deficit in fresh tomato production in the country.

Groundnut (peanut) is a major cash crop for the people of the three northern regions of the country. However, production can be found in all the regions of the country. Groundnuts are usually consumed as fresh, dry or roasted nuts and are also used in a variety of dishes (mostly stews and soups). Lower-grade oils can also be derived from the nuts with the waste from the extracts used as livestock feed or in the manufacture of soaps and lubricants. Apart from the economic importance of the nuts, the haulm is sold and used as livestock feed. Cowpea is a grain legume of economic importance and an important source of food, income and livestock feed. It forms a major component of tropical farming systems because of its ability to improve marginal lands through its nitrogen-fixing ability and its functions as a cover crop. It is extensively cultivated in the country under rain-fed conditions and consumed in various dishes.

Study design and data collection

The survey adopted the stratified multistage sampling design. Purposive sampling was used to identify the population that responded to the general questionnaire. Quota sampling was used to allocate the number of respondents per district. Snowballing was used to reach key informants for interviews. The sample size chosen for the study was calculated using Equation 1 from Campbell et al. (1995)

$$n = N*X/(X+N-1) \quad (1)$$

where

$X = Z_{\alpha/2}^2 * p(1-p)/MOE^2$

$Z_{\alpha/2}^2$ is the critical value of the normal distribution at α/2 (a confidence level of 98% was chosen, α=0.05 and the critical value is 1.96)

MOE is the margin of error

P is the sample population

N is the population

A questionnaire was used to solicit information from farmers and other stakeholders such as importers of agricultural machinery and equipment, local manufacturers and fabricators, agro-processors, service delivery and tractor operators, ministries and policymakers, research and universities and other key informants. The farmer household questionnaire covered the general background information of the selected farm settlement, the technical aspect involved in setting up the existing farm settlements, land preparation /tillage operation aspects and the identified type of types of machinery involved, planting/transplanting aspect, weeding/fertilizer application aspects, harvesting operation aspects, processing and storage aspects, farm transportation and handling aspects, and tractor operators/repair and maintenance. Information on the socioeconomic characteristics, educational level, and technical know-how of the farmers was elicited. The inventory of the farm machinery was also established.

A household questionnaire (using Epicollect5 software) was used for individual household/farmer data collection whilst key informant questionnaires and respondent-specific questionnaires were applied for interviewing the various respondents as identified in this survey. Questionnaires were administered at the farmers' farms and their residences. Data collected was compiled using Excel and analyzed with Stats. Graphs and tables were drawn and used for inferences. Some specific indices were calculated following steps and formulas for their derivation.

3.0 RESULTS AND DISCUSSION

Identified value chains of selected crops

The value chains identified are similar for maize, rice, groundnut and cowpea. The major differences in the value chain for these crops are seen at the post-harvest stages and

processing. The value chains begin from pre-production and end with marketing. The value chain does not take into consideration consumption as it is assumed that consumption happens after marketing. The maize value chain (Figure 1) is similar to the rice value chain (Figure 2) with the only differences seen in pre-production, post-harvest and processing stages. Land preparation activities under preproduction in the maize value chain differ from the same activity under rice. Production activities in maize in rice are similar whereas some post-harvest activities differ.

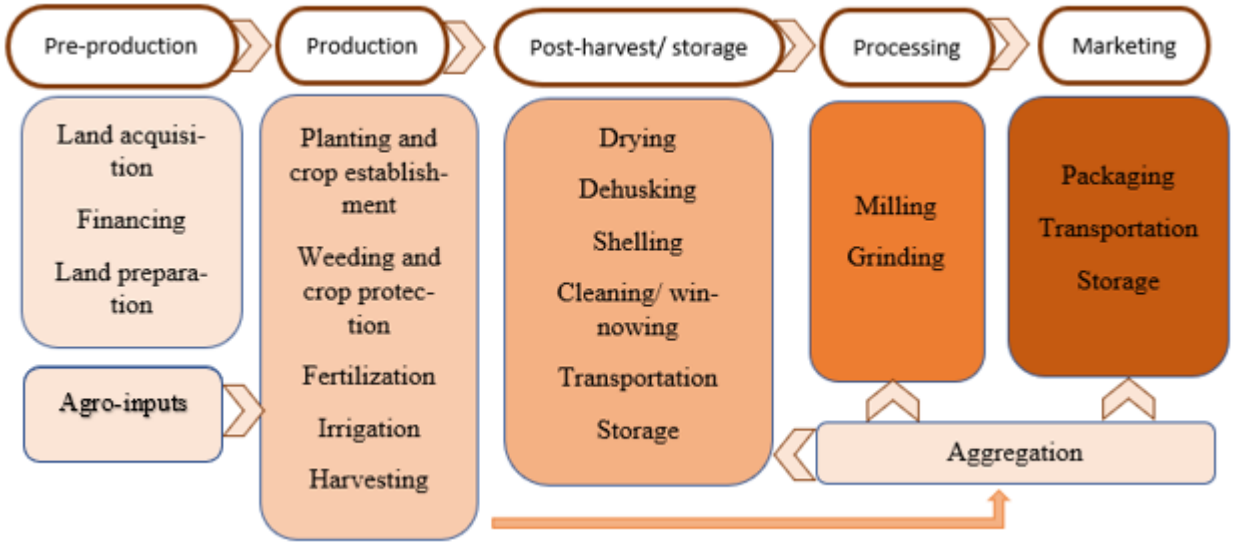

Figure 1: The Maize Value Chain in Ghana

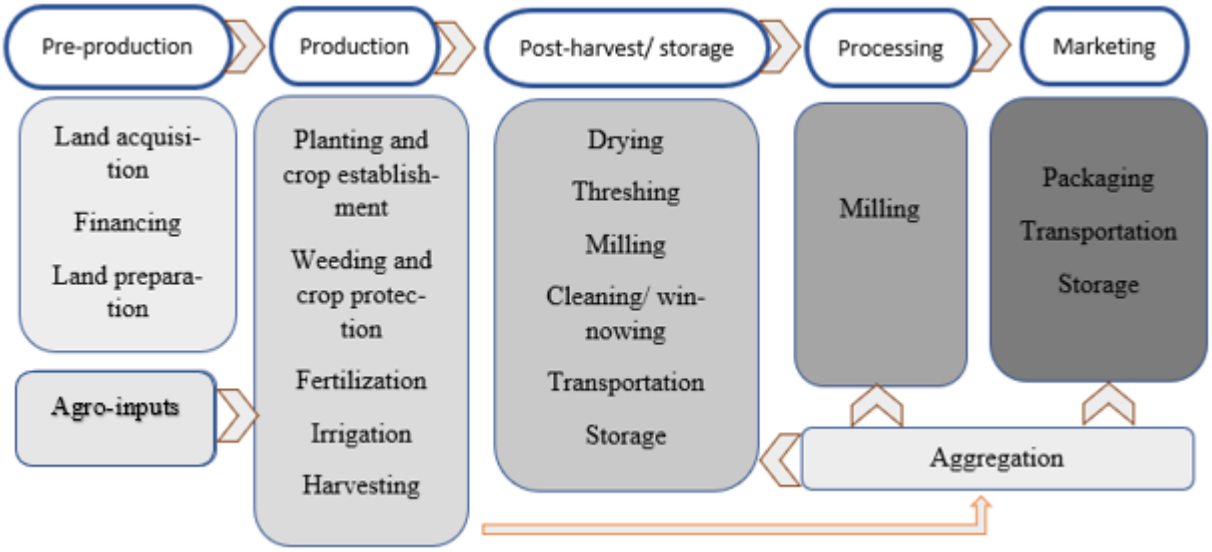

Figure 2: The Rice Value Chain in Ghana

Aggregation is a dominant feature with cereals (Figure 1 and 2) and legumes (Figure 3). Aggregators are collectors who take up farm produce from the farm gate and sometimes add value such as packaging for the market. Some aggregators double as financiers, who contract farmers to produce for them. With regards to cassava (Figure 4) and tomato (Figure 5), very little value addition is done at the farm level. Value addition is done mostly after collection or aggregation.

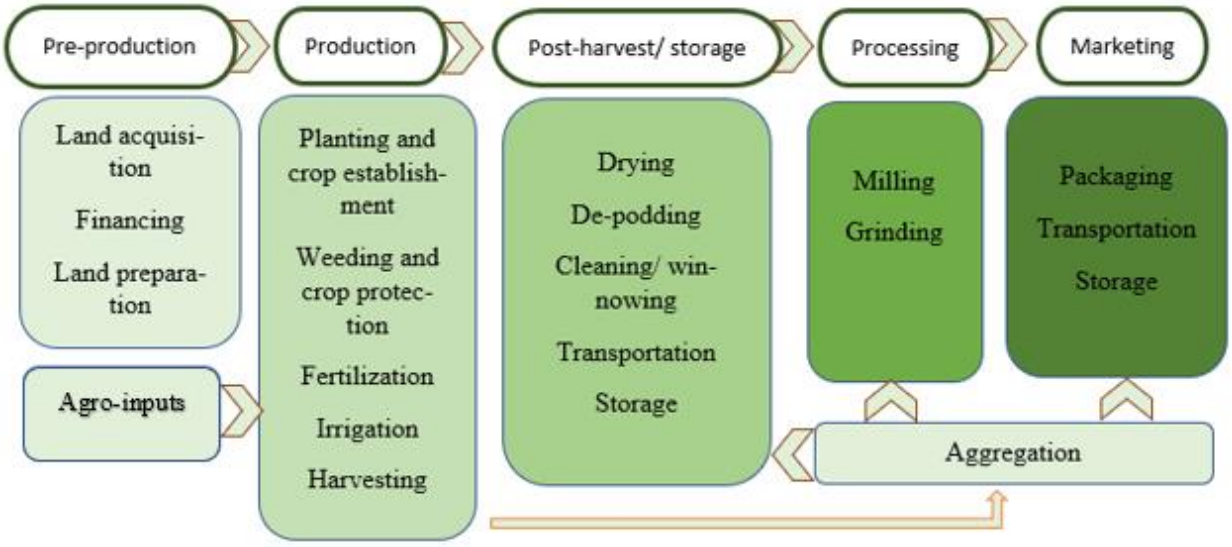

Figure 3 The Groundnut and Cowpea Value Chain

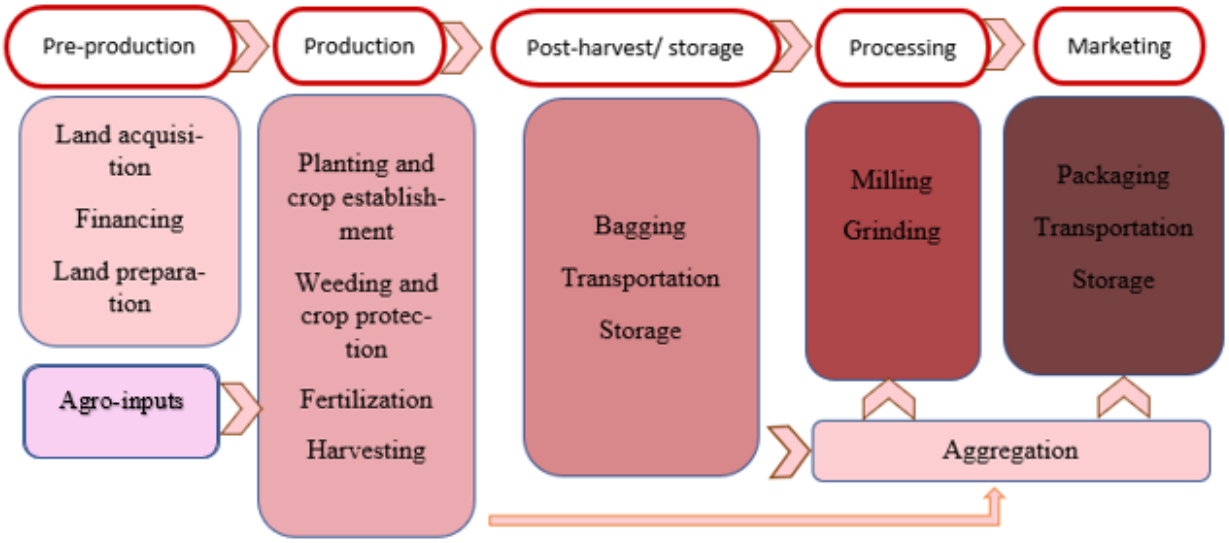

Figure 4: The Cassava Value Chain in Ghana

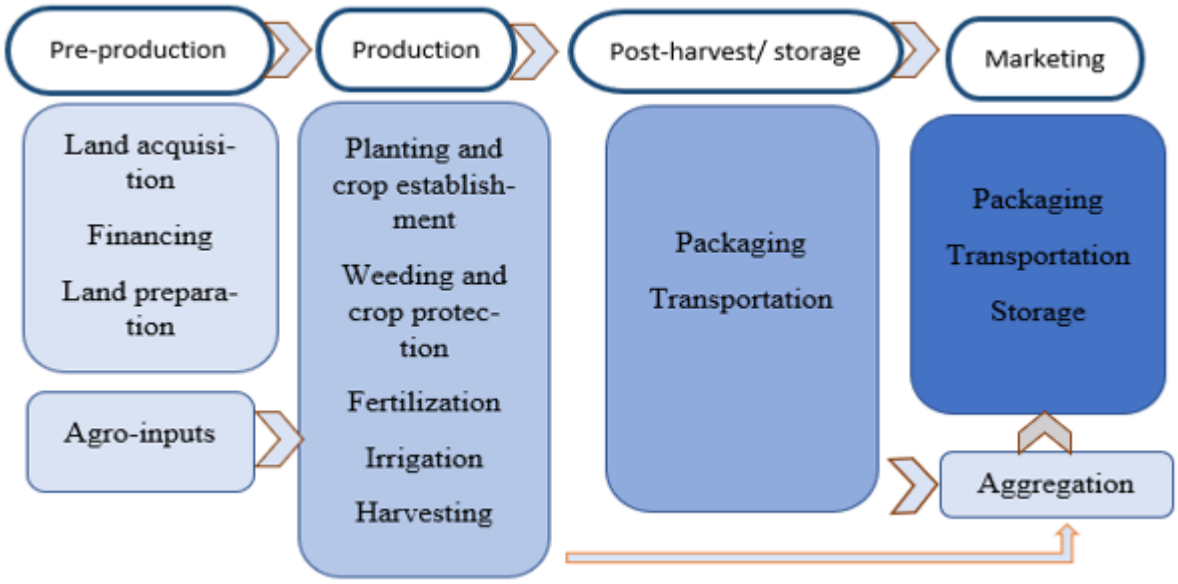

Figure 5: The Tomato Value Chain in Ghana

Maize is the dominant cereal crop grown across the country. This is followed by rice. Both crops are grown in all the regions of the country. However, production volumes differ across the regions. Groundnut and cowpea are predominantly grown in the forest transition zone of the Ashanti Region, the Bono, Ahafo and Bono East Regions, and the Northern, Savannah, Upper East and Upper West Regions of the country. Smaller volumes are grown in the country's Central, Greater Accra, Volta and Oti Regions.

Mechanization level of study crops

Mechanization levels differed across the regions of the country, though it behaved similarly for the major crops across the country. The mechanization level of the various crop commodity across the regions of the country is shown in Table 1. The Northern region had the highest level of maize mechanization (19.28%), while the Central region had the lowest (6.84%). Rice was most mechanized in Volta (21.28%) and least in Western (4.87%). Cassava mechanization was 6.79% in Savannah and Northern areas and 2.50% in Western North and Western. Tomato mechanization was highest in the Northeast and Upper East (14.92%) and lowest in the Western North (6.28%). Savannah, North East, and Upper East areas had the highest groundnut mechanization rate of 14.92%, while Ahafo had the lowest at 9.37%. Cowpea mechanization was highest in the Savannah, Northern, and Upper East regions (11.37%) and lowest in the Ahafo and Volta regions (8.50%).

Table 1: Mechanization Level for Selected Crops across the Regions

Region	Mechanization level of major crops (%)					
	Maize	**Rice**	**Cassava**	**Tomato**	**Groundnut**	**Cowpea**
Ashanti	14.25	16.48	5.29	10.46	-	9.00
Bono	15.82	18.82	3.28	12.28	12.28	9.82
Ahafo	17.63	19.75	3.28	10.46	9.37	8.50
Bono East	18.01	16.48	4.25	9.92	11.48	10.54
Central	6.84	14.85	3.28	11.37	-	-
Eastern	11.29	17.28	4.25	10.30	-	8.50
Greater Accra	14.98	17.28	3.28	10.38	-	-
Savannah	16.88	19.63	6.79	12.38	14.92	11.37
North East	14.89	18.75	5.50	14.92	14.92	10.54
Northern	19.82	19.49	6.79	13.87	12.28	11.37
Upper East	16.28	18.75	3.28	14.92	14.92	10.54
Upper West	12.92	15.58	3.28	10.38	12.38	11.37
Volta	11.28	21.28	4.25	9.92	11.48	8.50
Oti	13.12	14.85	3.28	9.92	12.38	9.37
Western North	10.28	11.92	2.50	6.28	-	-
Western	9.19	4.87	2.50	7.37	-	-

Northern, Bono East, Ahafo, Savannah Upper East and Bono regions had mechanization levels above 15%. In all regions, rice was the most mechanized crop, followed by maize, while cassava was the least mechanized. This might be attributed to the government's resolve to achieve national self-sufficiency in rice and maize through the Planting for Food and Jobs (PFJ) project and the related investment in the sector (Pauw, 2022). Western and Western North regions generally had the least level of crop mechanization while the Northern regions (Savannah, Northern, Upper West and Upper East) recorded the highest. The obtained result is consistent with the findings of a similar study by Akolgo et al. (2022), which indicated a mechanization rate of less than 20% for agricultural operations in Ghana.

Mechanization for the major value chains

Land preparation

Land preparation activities such as weeding, bush/land clearing, tree cutting and removal of stumps for lands that have not been previously tilled or cropped were primarily performed manually with no mechanized inputs for maize, rice, tomato, groundnut and cowpea. Tools and equipment used for these activities included knapsack sprayers (for chemical weed control), hoes, cutlasses/machetes, mattocks, and pickaxe (primary for stump removal).

For lands that have been previously cropped, some level of mechanization was seen in land preparation particularly weeding of fields prior to planting of maize (22.90%) (Figure 6) tomato (20.73%) (Figure 9), groundnut (16.36%) (Figure 10) and cowpea (23.47%) (Figure 11).

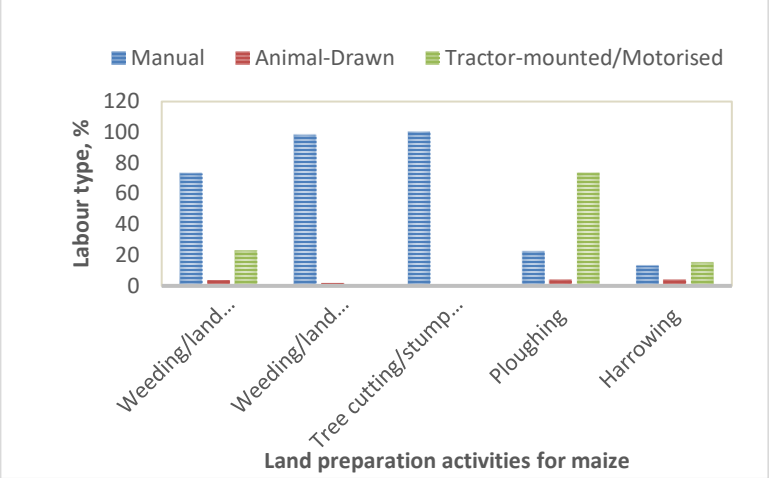

Figure 6: Variation of Labour Type for Land Preparation Activities under Maize Production

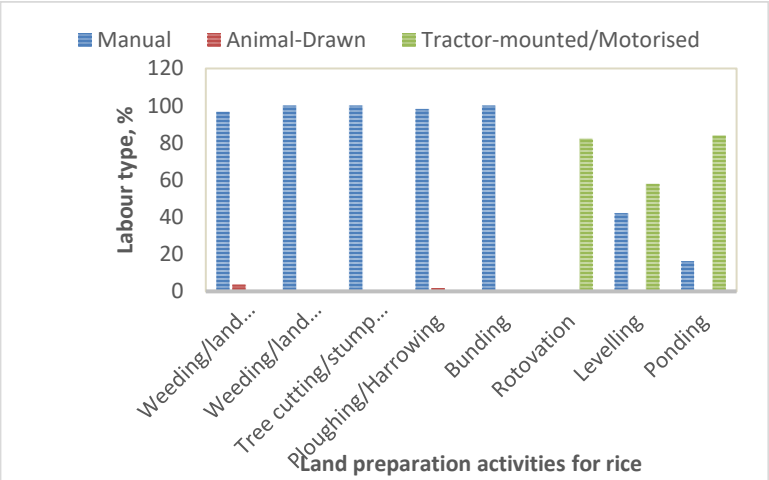

Figure 7: Variation of Labour Type for Land Preparation Activities under Rice Production

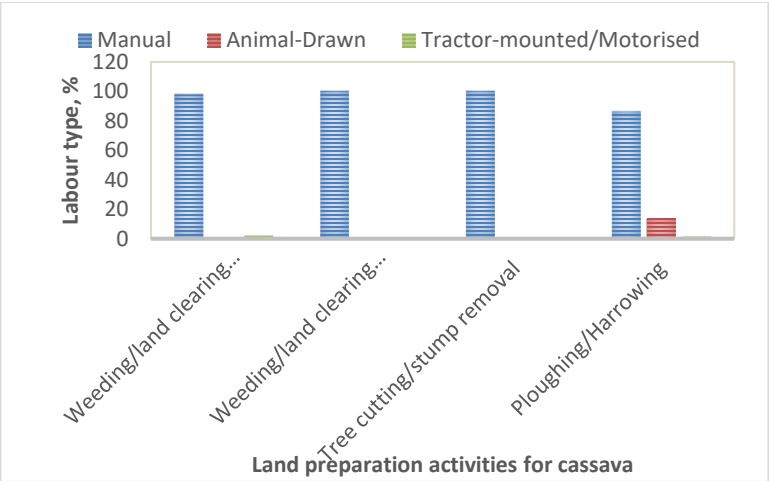

Figure 8: Variation of Labour Type for Land Preparation Activities under Cassava Production

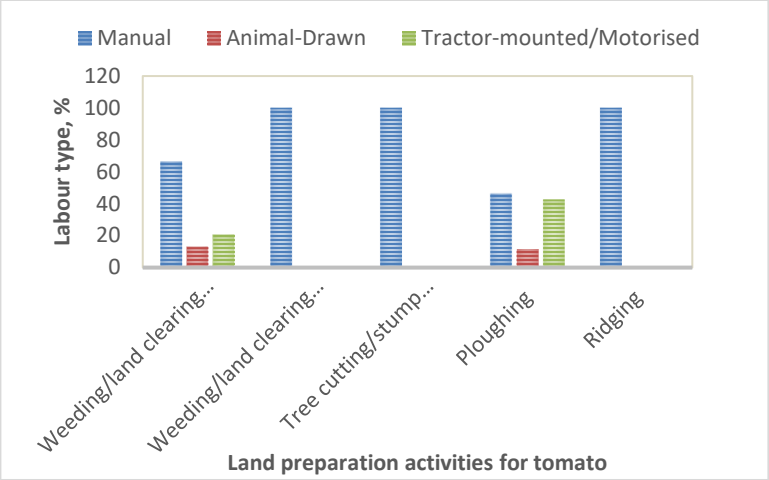

Figure 9: Variation of Labour Type for Land Preparation Activities under Tomato Production

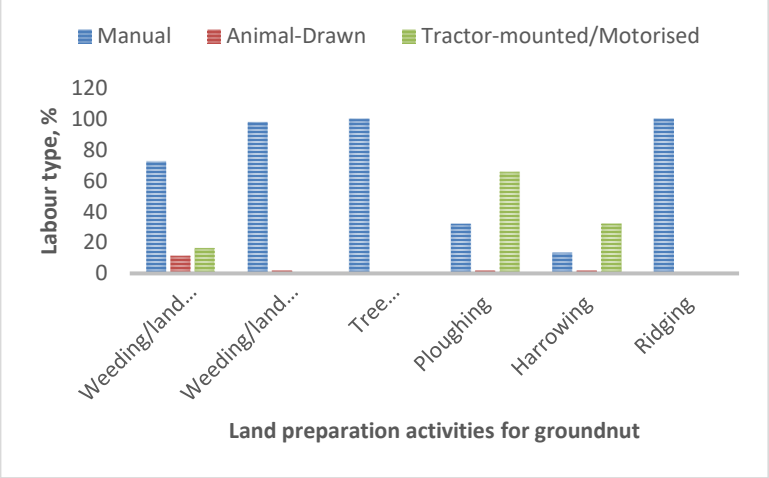

Figure 10: Variation of Labour Type for Land Preparation Activities under Groundnut Production

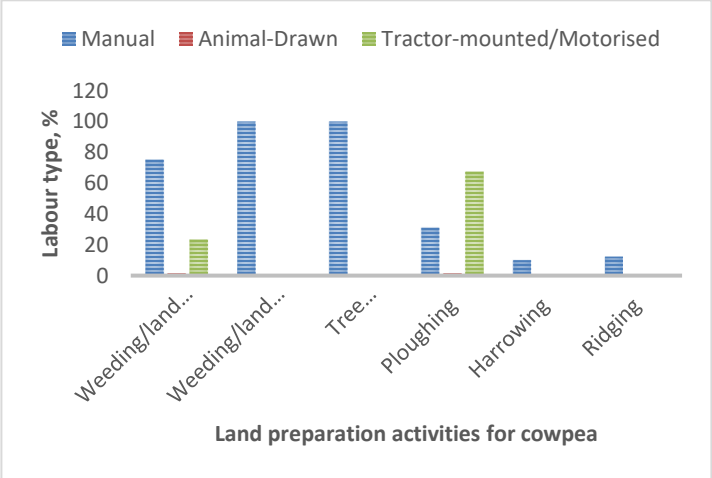

Figure 11: Variation of Labour Type for Land Preparation Activities under Cowpea Production

Ploughing with tractor-mounted implements was mostly done for maize (73.32%), tomato (42.58%), groundnut (65.69%) and cowpea (67.49%) (Figures 6, 9, 10 and 11 respectively). Animal-drawn implements were used in low proportion compared with tractor-drawn implements for activities such as weeding, ploughing and harrowing for maize, rice, groundnut and cowpea (Figures 6, 7, 10 and 11 respectively). It was also used for ploughing and harrowing in cassava and tomato production (Figures 8 and 9 respectively).

Mechanization levels for rotovating, levelling and ponding of rice fields were 82.14%, 57.87% and 83.76% respectively as shown in Figure 7. Manual labour was however still dominant in land preparation activities for all selected crops. The least mechanized activities were weeding and stump removal as well as bunding (in rice) and ridging in tomato, groundnut and cowpea. Labour for both manual and mechanized activities was influenced by gender. Male youth were dominant in manual, animal-drawn or mechanized activities in weeding, stump removal, rotovation, ploughing/harrowing, levelling and ponding. These are all labour-intensive activities.

As described by Pingali *et al.* (1987), the demand for mechanization emerges sequentially based on the different functions of the mechanization system being mechanized, the different types of mechanization technology and different categories of farmers. Power-intensive functions, beginning with ploughing and including threshing, milling and transport, are the first to be mechanized while control-intensive functions, such as weeding and winnowing, are mostly mechanized with improved income (Pingali *et al*. 1987). Stationary operations are typically mechanized before mobile operations (Rijk 1999). Demand for animal power, where it is used emerges before the demand for machine power (Pingali *et al*. 1987).

Planting and crop management

Planting activities for maize and rice were mechanized at a level of 10.26% (Figure 12) and 16.71% (Figure 13) respectively. The mechanized level for maize was due to the use of maize planters by some medium and large-scale farms. With respect to rice, dry seeds were usually broadcasted manually into bunded basins and ploughed in using the power tiller, thus the mechanized level experience. All nursed rice seedlings were transplanted manually.

Planting of groundnut and cowpea was slightly mechanized at 4.31% (Figure 16) and 6.72 % (Figure 17) respectively. Again, this was attributed to the use of cereal planters that were calibrated for use in planting these legumes by some medium-scale and large-scale farms. Tomato (Figure 15) was planted manually (100%) using nursed seedlings and hand tools such as cutlasses/machetes and dibbler. Similarly, cassava cuttings were solely planted manually (Figure 14).

Weed control and other pest/disease control were mechanized at 35.18% and 17.85% respectively for maize (Figure 12). Weeding activities were mainly done by tractor-mounted weeders/slashers or mowers whilst pests and diseases were controlled by chemical spraying using tractor-mounted sprayers, boom sprayers or knapsack sprayers.

Weed control in rice was done by either manually removing weeds by hand or spraying with selective weedicides using the knapsack sprayer. Weeds in tomato, cassava, groundnut, cowpea and cocoa were also controlled manually by either weeding with a hoe or cutlass/machete or by spraying with selective weedicide/herbicide using a knapsack sprayer. Irrigation in rice and

tomato was heavily mechanized at 91.28% (Figure 13) and 77.89% (Figure 15) respectively.

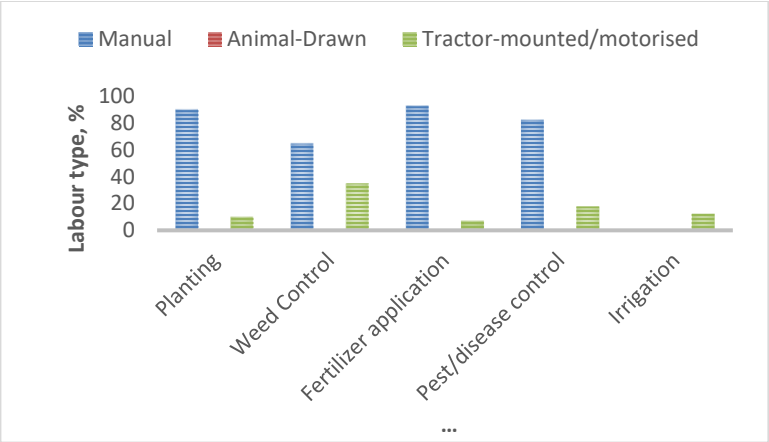

Figure 12: Variation of Labour Type for Planting and Crop Management Activities Under Maize Production

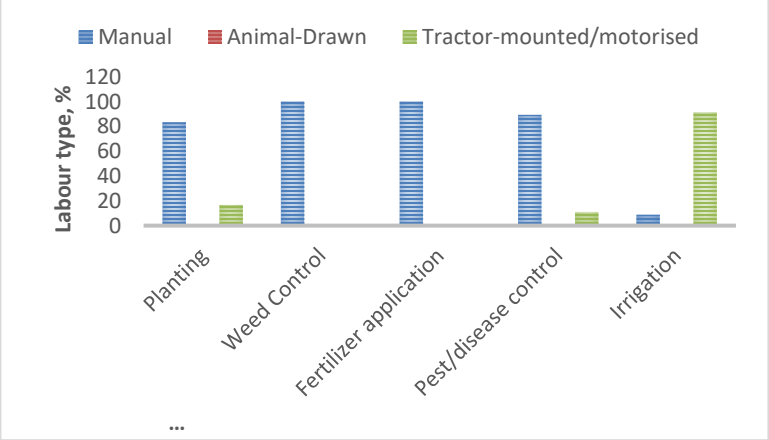

Figure 13: Variation of Labour Type for Planting and Crop Management Activities under Rice Production

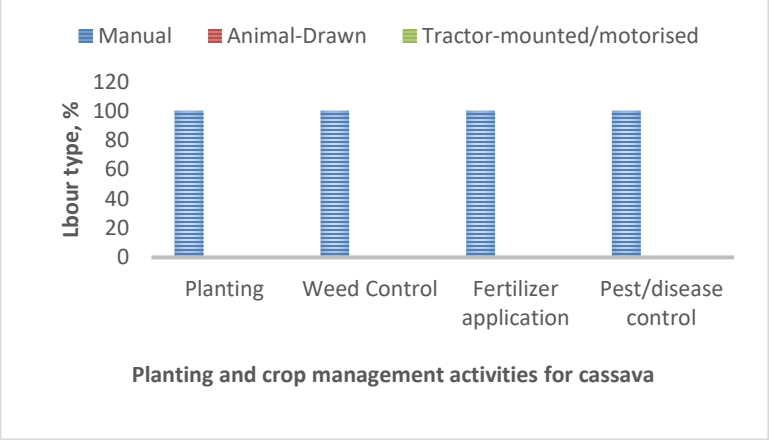

Figure 14: Variation of Labour Type for Planting and Crop Management Activities under Cassava Production

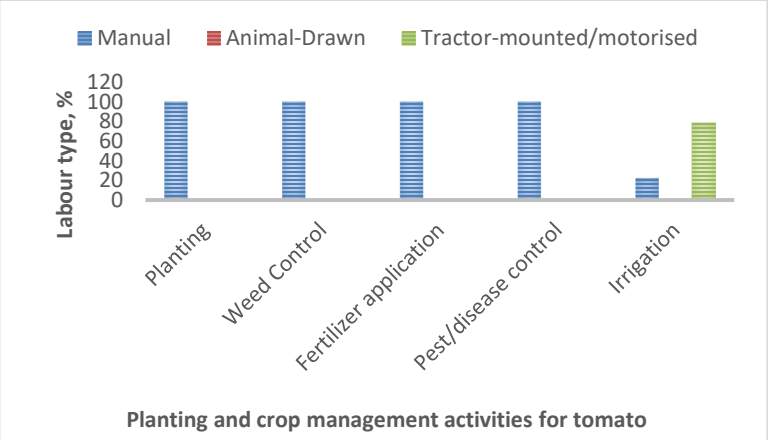

Figure 15: Variation of Labour Type for Planting and Crop Management Activities under Tomato Production

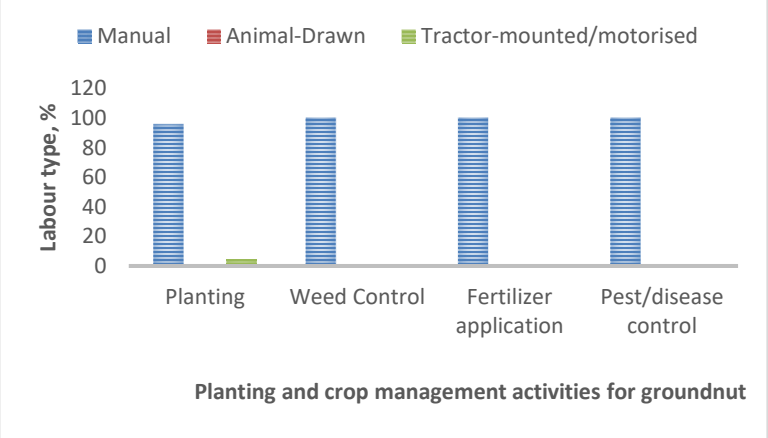

Figure 16: Variation of Labour Type for Planting and Crop Management Activities under Groundnut Production

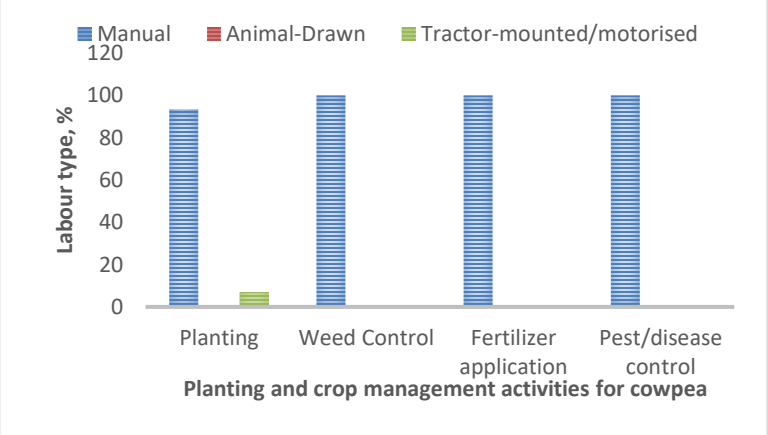

Figure 17: Variation of Labour type for Planting and Crop Management Activities under Cowpea Production

Harvesting and Post-Harvest

Harvesting was slightly mechanized for maize, cassava and groundnut at 7.69% (Figure 18), 1.13% (Figure 20), and 3.77% (Figure 22) respectively. Harvesting of rice was also fairly mechanized at 42.18% (Figure 19). The relatively high level of mechanization in rice could be attributed to the influx of rice harvesters in the rice-growing areas that were surveyed. The tomato was harvested 100% (Figure 21) manually by hand picking. The milling and polishing of rice were 100% mechanized (Figure 19).

Carting/transportation activities for all the crops were highly mechanized. Machinery and equipment used in transportation and carting included tractor-mounted trailers, motorcycles, tricycles with trailers, pickup vehicles and small trailer trucks. Animal-drawn implements constituted 12.28% (Figure 18), 13.48% (Figure 19), 8.24% (Figure 20) and 8.28% (Figure 22) of carting/transportation activities in maize, rice, cassava and groundnut respectively.

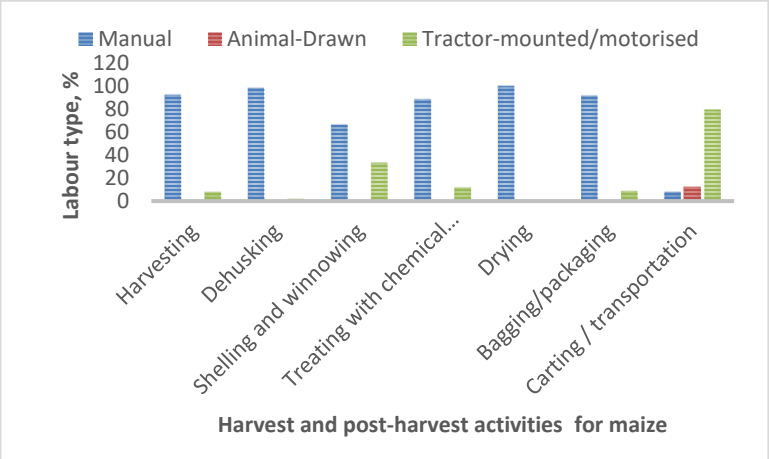

Figure 18: Variation of Labour Type for Harvest and Post-Harvest Activities for Maize Production

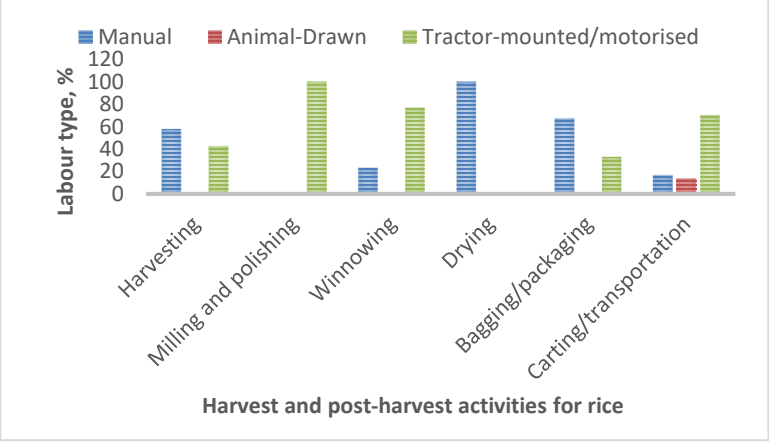

Figure 19: Variation of Labour Type for Harvest and Post-Harvest Activities for Rice Production

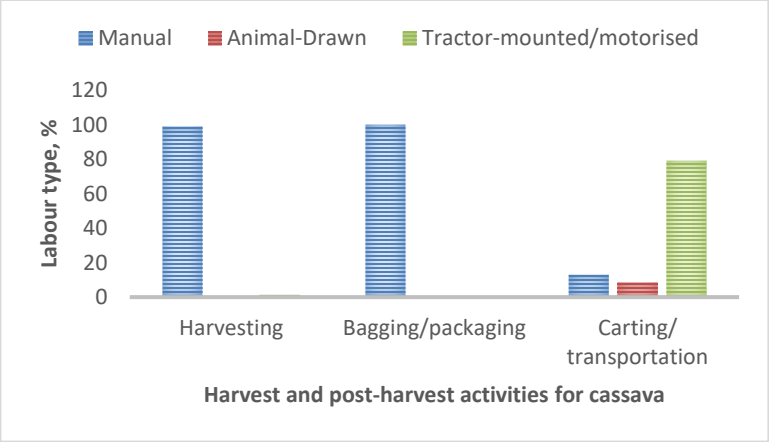

Figure 20: Variation of Labour Type for Harvest and Post-Harvest Activities for Cassava Production

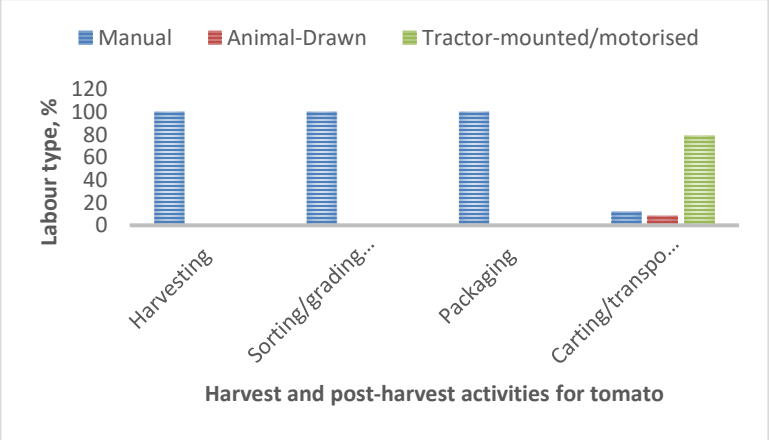

Figure 21: Variation of Labour Type for Harvest and Post-Harvest Activities for Tomato Production

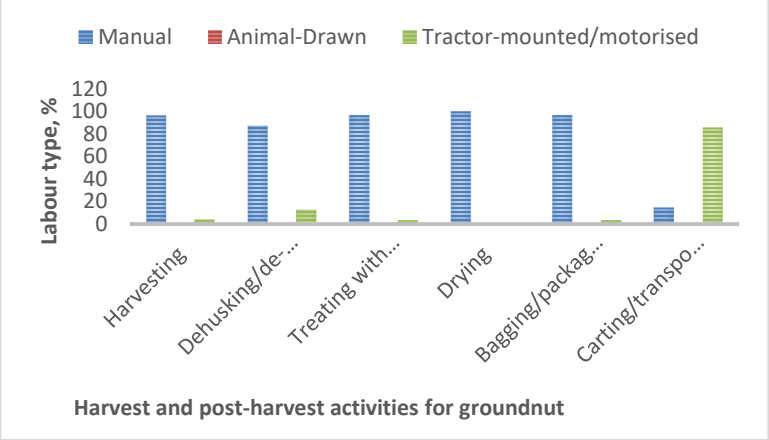

Figure 22: Variation of Labour Type for Harvest and Post-Harvest Activities for Groundnut Production

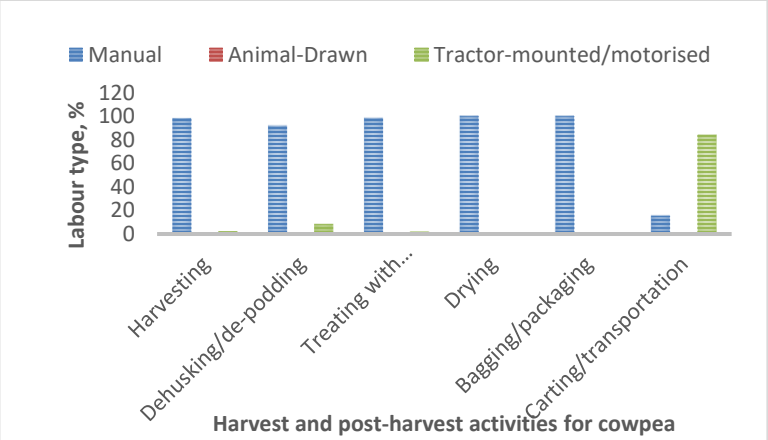

Figure 23: Variation of Labour Type for Harvest and Post-Harvest Activities for Cowpea Production

Storage

The storerooms are dedicated rooms for storing crop produce in the house of farmers whereas the home barn is a structure (usually roofed wooden structure) that is put up outside the abode of the farmer for the purpose of storing crop produce. Storerooms and home barns accounted for 52.36%, 20.49%, 21.64%, 43.23%, 48.54% and 77.38% (Table 9) of storage types for maize, rice, cassava, groundnut, cowpea and cocoa.

Community warehouses are storage structures built by the government, Non-Governmental Organizations (such as World Vision, Care, ADRA, etc.), Community-Based Organizations or Farmer Based Organizations. Usage of these facilities usually comes with subsidized storage charges.

Table 2: Storage Type and Percentage Usage/Adoption

Storage type	Usage by crop, %						
	Maize	Rice	Cassava	Tomato	Groundnut	Cowpea	Cocoa
Silos	11.58	15.34	-	-	12.65	10.28	-
Community Warehouse	14.21	8.29	-	-	18.90	14.32	-
Storeroom	29.45	20.49	12.36	-	34.87	40.18	38.92
Farm barn	5.38	39.45	18.42	-	13.28	9.29	11.22
Home barn	22.91	-	9.28	-	8.36	8.36	38.46
Farmhouse	16.47	-	-	48.22	11.94	17.57	11.40
Milling shop	-	16.43	-	-	-	-	-
Straight to market (No storage)	-	-	59.94	51.78	-	-	-

Value addition

Value addition was limited to maize, cassava and rice. Maize and rice were milled into flour for food and as ingredients in baby food. Maize was also milled in combination with some other ingredients especially, soya beans and used as feed in the poultry industry. Maize and cassava were also processed into dough for food. Groundnut was also roasted and/or milled into a paste for the food industry. Cassava was also processed into gari. Milling activities under these value-addition processes were done using the hammer and wet mill. Grading and sorting were done manually for tomatoes.

4.0 CONCLUSION

The study sought to identify relevant crop value chains, assess the levels of mechanization for the identified value chains and proposed recommendations to promote the adoption of appropriate mechanization technologies in Ghana. The relevant value chains identified across the 16 regions were pre-production, production, post-harvest/storage, processing, and marketing for six (6) major staple crops, namely maize, rice, cassava, tomato, groundnut, and cowpea. The level of mechanization ranged from 21.3% for Rice in the Volta region to 2.5% for Cassava in the Western North and Western regions. Generally, the level of mechanization was highest for Rice across the regions, whereas Cassava recorded the least.

The low level of agricultural mechanization across regions and food crop value chains can be ascribed to past failed attempts to modernize agricultural output based on the erroneous impression that importing tractors and implements was sufficient. Unquestionably, a mechanized revolution is necessary to alter the narrative, and every effort should be made in this direction. Government and private stakeholder assistance could consider generating local content by teaching and supporting agricultural engineers to develop locally demand-driven innovations while increasing their repair and maintenance capabilities for imported machines. A more sustainable strategy for raising the status of agricultural mechanization in an effort to modernize Ghana's agriculture is to make a concerted effort to create local competence in the development of demand-driven agricultural technology. It is recommended that policies be developed to incorporate such strategies into the country's educational system.

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