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Ghana Circular Economy Centre

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Republic of Ghana

CIRCULAR ECONOMY OPPORTUNITY MAP

Ghana Cassava Value Chain

SEPTEMBER, 2025

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Authors

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About This Report

This report maps circular economy opportunities within the cassava value chain to inform policymakers, development partners, and private sector actors. The sections progress from value chain context and baseline analysis to opportunity identification and practical recommendations, providing a coherent basis for action and investment.

Executive Summary

Agriculture and agro-processing value chains are responsible for the production, processing, trading and distribution of all agri-food commodities and products across national, sub-regional, regional and global markets to satisfy both domestic (household) and industrial demands. This Circular Opportunity Mapping Study was commissioned by UNIDO as part of Ghana's effort to transition from a linear to a circular economy along the agriculture and agroprocessing value chains. The main objective of this study was to map out the circular economy opportunities along the cassava value chain in Ghana.

We combined desk review, field survey and key informant interviews to gather data for this circular opportunity mapping and baseline assessment. The exercise was undertaken in the Ashanti and Bono East regions which represent important centers with high concentration of cassava value chain activities including production, processing and trading/marketing. Mampong Municipality and Sekyere Central district were selected in Ashanti region together with Techiman Municipality in the Bono East Region for the survey. A total of 765 value chain actors comprising 465 producers, 198 processors and 102 traders were selected across 20 communities and six markets through a combination of purposive, stratified sampling, simple random and snowball sampling techniques. Personal interviews were adopted to elicit information on basic socio-demographic characteristics and input-output data for the Material Flow Analysis (MFA) and Lifecycle Assessment (LCA). Information on material use, byproducts and waste generation, recycling/reuse as well as losses along the value chain were gathered. Constraints faced by actors at each node of the value chain were ranked on a five-point Likert scale (1=strongly disagree and 5=strongly agree). Field data collected was analyzed by employing basic descriptive tools such as frequency distribution tables, arithmetic mean, proportions and charts. The MFA and LCA assessment were done with technical support from UNIDO.

A total of **765 value chain actors** comprising **465 producers, 198 processors and 102 traders** were selected across **20 communities**

and **six markets** through a combination of purposive, stratified sampling, simple random and snowball sampling techniques.

The key observations and findings from the study are summarized as follows:

- **Yield & Labour:** Median cassava yield was estimated at ~6,000 kg/acre which is comparable to a typical farmer in Ghana. The average labour productivity of ~75 kg/manday indicates high labour intensity in production, pointing to potential inefficiencies on-farm largely to labour-intensive technologies adopted at the production node of the value chain.

- **Losses & Waste:** Producers lose on average ~7% of harvest; processors lose ~4% of output and traders lose ~4–6% of the total volume handled per monthly trading cycle. These losses (due to damage, spoilage or inefficiency) represent leakage in the value chain which need to be reduced by adopting appropriate circular innovations. High volume of effluent (liquid starch) is lost during the pressing of milled cassava before roasting. This represents a huge circular opportunity for valourization.

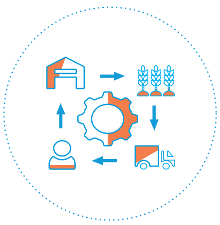
- **Byproducts:** Processors generate small byproduct amounting to ~2.6% of input weight. Study revealed that about 60% of cassava peels are reused as animal feed, leaving 40% of peels as waste which suggests a circular economy opportunity by redirecting the remaining peels to compost and professionally packaged livestock feed to close resource loops.

- **Energy & Resource Use:** Processing is relatively energy-intensive (on average ~2.7 kg firewood per kg of product). This heavy reliance on firewood (for frying/roasting) is a hotspot for circular action, where fuel-efficient ovens could be designed and deployed to cut down on fuel consumption and waste. Water usage was quite high at the farm level. However, at both processing and trading nodes of the value chain, water usage was very modest on a per-kg basis, but any savings would also bring in some circular benefits (e.g. reusing wastewater).

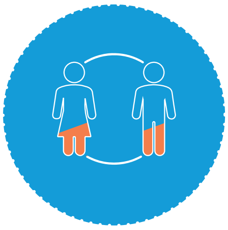
- **Transport Efficiency:** Fuel use per kg is low at ~0.04 L/kg for producers and ~0.01 L/kg for traders, but absolute farm-level fuel use was found to be quite high (mean ~132 L/farm to transport harvest). Transport inefficiencies and poor logistics planning are a circular leak (excess energy use) that improved logistics could fix. Aggregation of loads or better logistics planning could reduce per-farm fuel needs.

- **Environmental impacts:** In terms of environmental footprint, the LCA revealed that the processing node of the cassava value chain generates significantly high amount of GHG (494,081 kg CO_2eq) and toxic emissions (29,565kg) compared to the production and trading nodes.

- **Overall Circular Opportunities:** The study identified three most urgent circular hotspots. First relates to energy use in processing, where firewood dependency leads to extremely high energy intensity (~17 MJ/kg product), threatening forest resources and sustainable energy use. The second is about high volume of unused cassava peels which represents a missed opportunity for byproduct valorization in terms of animal feed, compost, or renewable energy feedstock (e.g., biogas). The third has to do with the high volume of effluent (liquid starch) that is lost during pressing and fermentation of milled cassava at the processing node of the value chain. This also presents a circular opportunity for valourization to produce environmentally friendly herbicide for weed control in smallholder farming systems in Ghana.



- **Constraints at each node of the value chain:** Among cassava producers, limited knowledge about alternative uses of production waste, erratic rainfall, limited access to improved production technologies, high cost of labour and limited access to land were identified as the key constraints. For processors, the key constraints were found to include limited knowledge about circular opportunities, limited access to improved processing technology, limited knowledge about improved processing methods and high cost of raw materials (cassava tubers and firewood). However, at the trading node of the value chain, the most pressing constraints were high cost of raw material (cassava), high cost of transportation, limited knowledge about circular opportunities in the value chain and limited access to quality raw materials.



- **Gender Balance and social capital:** While producers are evenly split by gender (~50% women), men are under-represented at the processing and trading nodes of the value chain. However, this is quite consistent across major cassava growing regions in Ghana. The low representation of value chain actors in cooperatives shows very low social capital in the cassava value chain. This social hotspot requires attention: engaging more actors, especially women in cooperative activities will enhance social capital, leading to improved access to productive resources, extension services, financial resources, as well as training and capacity building opportunities.

Based on the findings from the study, the following recommendations are made:

i. Energy efficient ovens should be designed, tested and promoted for use by women processors in the cassava value chain to improve energy usage, reduce GHG and toxic emissions associated with cassava processing.

ii. Circular innovations leading to the valourization of cassava peels into compost and animal feed should be explored in a participatory approach with the key actors in the value chain.

iii. Circular innovations for the collection of effluent (liquid starch) during cassava processing and its valourization to produce a bio-herbicide should be explored in Ghana by local fabricators and scientists respectively.

iv. Efficient logistics arrangements for transporting farm inputs (planting materials and water for herbicide application) and harvested cassava tubers/roots should be promoted in Ghana through training and capacity building.

v. In implementing circular innovations along the cassava value chains, a gendered approach is recommended to account for the imbalance in resource endowment and access, as well are productivity differentials between males and females.

vi. The strengthening of existing cooperatives and formation of new ones in the cassava value chain is recommended to improve collaboration and social capital for operational efficiency.

Based on the current study, an action plan has been developed and a number of steps to be followed to transition from the current linear to a more circular economy in agriculture and agro-processing value chains have been outlined.

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1. CONTEXT AND BACKGROUND

This section describes the context and background to the circular opportunity mapping exercise. It starts with a brief overview of the agriculture and agro-processing industry, highlighting some features of the three value chains under the agriculture and agro-processing pillar of the Ghana circular economy project. The section also provides the scope of the circular opportunity mapping exercise, and the methodology/approach followed to undertake the study.

1.1 Industry Overview

This subsection provides a general overview of the agriculture and agro-processing value chain with emphasis on the three priority value chains selected for the circular economy project in Ghana.

The agriculture and agro-processing industry contributes significantly to socioeconomic development through global trade, employment generation and household food and nutrition security. According to the International Labour Organization (ILO)[1], the agricultural sector contributed about 26% to global employment and over 50% of total employment in developing economies in 2019. In Ghana, the sector contributes about 19% to national GDP[2], employs about 54% of the active labour force and generates significant export earnings to fuel the growth and development of the country. Agriculture and agro-processing value chains are responsible for the production, processing, trading and distribution of all agri-food commodities and products across national, sub-regional, regional and global markets to satisfy both domestic (household) and industrial demands.

According to the International Labour Organization (ILO)1, the agricultural sector contributed about **26%** to global employment and **over 50%** of total employment in developing economies in **2019.**

In Ghana, the sector contributes about **19%** to **national GDP2**, employs about **54%** of the **active labour force** and generates significant export earnings to fuel the growthand development of the country.

1 ILOSTATS (2021). Statistical Database of International Labour Organization (https://ilostat.ilo.org/)

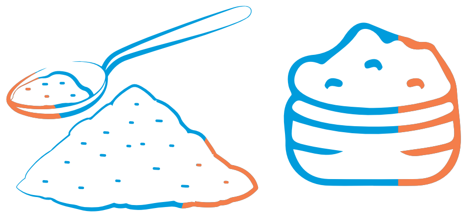
2 GSS Newsletter_Quarterly_GDP_2024_Q4_March_2025 Edition_GSS.pdf (www.statsghana.gov.gh/)

Our priority agriculture & agro-processing value chains for the Ghana circular economy project include roots and tubers (Cassava), fruit crops (Mango and Pineapple) and Fish value chains.

Root and tubers value chain

Root and tubers are strategic food security crops whose value chains employ millions of people in Ghana. The key actors include input suppliers, many smallholder farmers as primary producers, processors who convert the fresh produce into various value-added and derived products, as well as aggregators, traders, and third-party logistics companies that support distribution of the products across Ghana and beyond. The most popular root and tuber value chain is the cassava value chain with a very vibrant processing node that employs many women and youth. The value chain of cassava extends beyond the borders of Ghana. Exporters and business entrepreneurs outside Ghana distribute the derived products to retail shops abroad for the ever-growing African community in Europe and North America. Derived products like gari, starch, agbelima are processed at both cottage and industrial levels with serious challenges for waste disposal and management. The effluent from gari processing is an could be gathered through innovative engineering approaches to be converted into starch or weedicides since initial assessment suggests it has some herbicidal properties. There is great potential to further process the peels from cassava processing into compost for farmers to fertilize their soils and animal feed for sale to livestock farmers, especially during the dry season when animal feed is scarce and expensive. The possibility of generating biogas energy to serve as fuel for the processing activity that currently relies heavily on fuel wood could also be an innovative way of promoting circularity and environmental sustainability.

Exporters and **business entrepreneurs** outside **Ghana** distribute the derived **products** to retail shops **abroad** for the ever-growing **African community** in **Europe** and **North America**. Derived products like **gari, starch, agbelima** are processed at both cottage and industrial levels with serious challenges for **waste disposal** and **management.**



Fruit crop value chain

Fruit crops (mango and pineapple) are very important for the Ghanaian economy, employing many people in primary production, processing and distribution. The processing node is dominated by small/medium scale enterprises and very few large-scale industrial processors who target markets outside Ghana to sell over 70% of their products. The high levels of postharvest losses recorded at the production node (50%) suggest that serious attempts should be made to understand the challenges of the cottage-level processors to build their capacities and expand their processing scales to absorb significant volumes of fresh fruits for value addition. Technologies like solar drying, biomass drying and cold storage of the puree during the peak harvest season hold great potential in reducing the significant losses along the chain. The use of fruit peels to produce other products like mosquito coils and organic fertilizers (compost) also present viable business opportunities to be explored and exploited by the youth. Already, KNUST has a small-scale fruit juice processing factory which is about to add dry mangoes as a product line. Expanding the capacity of this facility and other facilities in the mango and pineapple belt of Ghana would help reduce losses, create employment, improve incomes and help reduce greenhouse gas (GHG) emissions resulting from the food losses and rather promote environmental, social and economic sustainability.

Fish Value Chain

Fish is an important source of animal protein in Ghana. The fish value chain has actors who supply inputs (e.g. fingerlings, fish feed, nets), fish farmers and fishermen, fish processors (who are mostly women) and fish traders (wholesalers and retailers) across all major markets in Ghana. At the feed production node, innovative approaches could lead to pelletized feed made from root and tubers residues to promote circularity. Climate smart fish farming methods that integrate aquaculture with vegetable production could be promoted to ensure that wastewater from fishponds is used to water and fertilize vegetable farms. At the processing node, significant waste products have the potential to be used in animal feed production (to be sold for dog owners in urban centers) and organic compost preparation together with residues from cassava and fruits after processing. There is a significant export dimension to the fish value chain where dry and smoked fish are exported to Europe and North America to the growing diaspora community. The proposed project will help us have a complete map of the value chain, identify all the bottlenecks and propose best innovative ideas that will promote environmental sustainability while creating viable businesses for the youth and women. There are circular opportunities along the three selected value chains that need to be identified, validated and confirmed for further exploration under the Ghana circular economy project. This circular opportunity mapping and baseline exercise was conducted to further this course.

1.2 Scope of the Opportunity Mapping Exercise

The main objective of the study was to map out the circular economy opportunities along the cassava value chain in Ghana.

The scope of the assignment included the following:

i. Value chain actors' identification and activity mapping.
ii. Material Flow Analysis (MFA) and Lifecycle Assessment (LCA) along the cassava value chain.
iii. Determination of circular economy opportunities at each node of the value chain.
iv. Identification of key constraints faced by actors in the Cassava value chain
v. Development of Action Plan to explore the viability of the circular economy opportunities identified; and
vi. Make recommendations for further action based on key findings.

1.3 Approach/Methodology

We combined desk review, field survey and key informant interviews to gather data for this circular economy mapping and baseline assessment.

The current study focused on actors in the Cassava value chain. The exercise was undertaken in the Ashanti and Bono East Regions which represent important centers with high concentration of cassava value chain activities including production, processing and trading/ marketing. Mampong Municipality and Sekyere Central district were selected in Ashanti region together with Techiman Municipality in the Bono East Region for the survey. About 20 communities and six markets were purposively selected for the study. The level of cassava processing and production activities informed the choice of communities.

About **20 communities** and **six markets** were purposively selected for the **study.**

A stratified sampling approach was adopted to ensure that all actor categories were adequately represented in the study. The subsamples for each actor category selected from the two regions are presented in Table 1. In all, 765 actors comprising 465 producers, 198 processors and 102 traders were covered during the survey.

In each community, nearly all processing centers were visited and as many processors that were available and willing to participate in the study were selected for interview. For producers of cassava, a convenient sampling approach was adopted to select cassava farming households. In the food markets visited in Mampong, Techiman, Nsuta, etc., all available wholesalers and retailers of fresh cassava roots (tubers) and cassava products (e.g. dough, cassava flour) were contacted for interview.

Table 1: Cassava value chain actors sampled for the study

Location	Producers		Processors		Traders		Pooled Sample	
Region:	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Ashanti	211	45.4	83	41.9	41	40.2	335	43.8%
Bono East	254	54.6	115	58.1	61	59.8	430	56.2%
Total	**465**	**100.0**	**198**	**100.0**	**102**	**100.0**	**765**	**100.0%**
District:								
Mampong	130	28.0	35	17.7	25	24.5	190	24.8%
Techiman	254	54.6	114	57.6	62	60.8	430	56.2%
Sekyere Central	81	17.4	49	24.7	15	14.7	145	19.0%
Total	**465**	**100.0**	**198**	**100.0**	**102**	**100.0**	**765**	**100%**

The research team developed comprehensive data collection instruments for the three value chain actor categories (Producers, processors and traders). The draft instruments were pilot-tested at Kwaaso in the Ejisu district in Ashanti region. The final questionnaires/instruments were programmed onto mobile android tablets using the Open Data Kit (ODK) software. A total of seventeen (17) enumerators were recruited and trained for data collection. Two teams were deployed to each of the regions to ensure that data collection went on concurrently.

Data collection was done through face-to-face personal interviews. In addition, key informant interviews were combined with personal observations to gather anecdotal evidence on the ground.

The interviews elicited information on basic socio-demographic characteristics and input-output data for the Material Flow Analysis (MFA) and Lifecycle Assessment (LCA). Information on material use, byproducts and waste generation, recycling/reuse as well as losses along the value chain were gathered. Constraints faced by actors at each node of the value chain were ranked on a five-point Likert scale (1=strongly disagree and 5=strongly agree).

Data collected was downloaded from the clouds in CSV and MS Excel format and exported to SPSS for cleaning, processing and analysis. Basic descriptive tools such as frequency distribution tables, arithmetic mean, proportions and charts were used to summarize the characteristics of actors and the constraints faced.

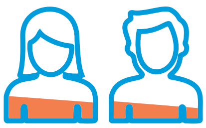
The Material Flow Analysis (MFA) and Lifecycle Assessment (LCA) were done with technical support from UNIDO.

2. VALUE CHAIN MAPPING AND BASELINE ASSESSMENT

This section begins with the characteristics of the value chain actors covered in the study, followed by value chain mapping and assessment of the baseline situation regarding material flows during value chain activities and their effects on the environment.

2.1 Summary characteristics of Actors

Table 2 provides the socio-demographic characteristics of cassava producers, processors and traders covered in the survey. Overall, the cassava value chain is dominated by females (68%), especially at the processing and trading nodes. In terms of production, it was almost a split between males and females. However, it is important to note that production of cassava tends to be a household activity that is undertaken by both males and female household members for the sustenance of the household. This, notwithstanding, cassava farms owned exclusively by female members of the household were not uncommon.



The **youth** constitute about **24%** of the actors in the **cassava value chain** while the aged **(>60 years)** formed only **13%** of the actors in the chain. This suggests that the majority **(63%)** of cassava value chain actors are adults who are **economically active.**

The youth constitute about 24% of the actors in the cassava value chain while the aged (>60 years) formed only 13% of the actors in the chain. This suggests that the majority (63%) of cassava value chain actors are adults who are economically active. The cassava value chain in the Ashanti and Bono East regions is dominated by actors with very low educational level. Only 17% of the actors sampled had attained secondary level of education and beyond. This low literacy rate indicates that any technology transfer or skills training should be packaged and delivered in the local language to ensure full comprehension and assimilation to improve uptake.

Since the study targeted actors at specific nodes of the value chain, majority of the actors interviewed considered their current cassava value chain activity as their primary occupation (Table 2b). Only about 5% of the producers of cassava considered farming as their secondary occupation. About 30% of cassava processors and 23% of traders were found to engage in farming as a secondary occupation.

Table 2a: Characteristics of Value Chain Actors sampled

Variable	Producers		Processors		Traders		Pooled Sample	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Sex of respondent								
Female	235	50.5	185	93.4	100	98.0	520	68.0%
Male	230	49.5	13	6.6	2	2.0	245	32.0%
Total	**465**	**100.0**	**198**	**100.0**	**102**	**100.0**	**765**	**100.0%**
Age of respondent								
<36 years	85	18.3	69	34.8	26	25.5	180	23.5%
36-39 years	48	10.3	32	16.2	21	20.6	101	13.2%
40-49 years	127	27.3	42	21.2	30	29.4	199	26.0%
50-60 years	123	26.5	44	22.2	22	21.6	189	24.7%
>60 years	82	17.6	11	5.6	3	2.9	96	12.5%
Total	**465**	**100.0**	**198**	**100.0**	**102**	**100.0**	**765**	**100.0%**
Educational level								
None	92	19.8	41	20.7	12	11.8	145	19.0%
Basic	291	62.6	128	64.6	72	70.6	491	64.2%
Secondary	66	14.2	25	12.6	16	15.7	107	14.0%
Tertiary	16	3.4	4	2.0	2	2.0	22	2.9%
Total	**465**	**100.0**	**198**	**100.0**	**102**	**100.0**	**765**	**100.0%**
Marital status								
Single, never married	61	13.1	36	18.2	11	10.8	108	14.1%
Married	314	67.5	126	63.6	71	69.6	511	66.8%
Separated/ Divorced/ widowed	90	19.4	36	18.2	20	19.6	146	19.1%
Total	**465**	**100.0**	**198**	**100.0**	**102**	**100.0**	**765**	**100.0%**
Religion								
Christianity	401	86.2	173	87.4	89	87.3	663	86.7%
Islam	43	9.2	21	10.6	13	12.7	77	10.1%
Traditionalist	7	1.5	1	0.5	0	0	8	1.0%
Others	14	3.0	3	1.5	0	0	17	2.2%
Total	**465**	**100.0**	**198**	**100.0**	**102**	**100.0**	**765**	**100.0%**

Source: Field Survey, 2025.

The cassava value chain is quite inclusive with about 21% of actors being settlers (non-natives) in the communities. However, cooperative membership was found to be very low, with only 15% of value chain actors belonging to one association or the other. This indicates a low level of social capital which is necessary for resilience in the face of shocks.

Table 2b: Characteristics of Value chain actors sampled

Variable	Producers		Processors		Traders		Pooled Sample	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Primary occupation								
Farming	441	94.8	17	8.6	12	11.8	470	61.4%
Salaried work	9	1.9	2	1.0	0	0	11	1.4%
Agro-processing	3	0.6	175	88.4	0	0	178	23.3%
Trading	8	1.7	3	1.5	90	88.2	101	13.2%
Other	4	0.9	1	0.5	0	0	5	0.7%
Total	**465**	**100.0**	**198**	**100.0**	**102**	**100.0**	**765**	**100.0%**
Secondary occupation								
Farming	31	6.7	67	33.8	24	23.5	122	15.9%
Salaried work	9	1.9	-	-	-	-	9	1.2%
Agro-processing	33	7.1	19	9.6	2	2.0	54	7.1%
Trading	102	21.9	18	9.1	6	5.9	126	16.5%
Other	38	8.2	7	3.5	2	2.0	47	6.1%
None	252	54.2	87	43.9	68	66.7	407	53.2%
Total	**465**	**100.0**	**198**	**100.0**	**102**	**100.0**	**765**	**100.0%**
Residential Status								
Native	387	83.2	145	73.2	73	71.6	605	79.1%
Non-native	78	16.8	53	26.8	29	28.4	160	20.9%
Total	465	100.0	198	100.0	102	100.0	765	100.0%
Member of Cooperative								
No	401	86.2	157	79.3	91	89.2	649	84.8%
Yes	64	13.8	41	20.7	11	10.8	116	15.2%
Total	465	100.0	198	100.0	102	100.0	765	100.0%

Source: Field Survey, 2025.

2.2 Cassava Value Chain Stages

The activity flow and stages in the Ghanaian cassava value chain have been outlined in Figure 1. Like any crop value chain, activities along the cassava value chain start from site selection and land preparation through quality planting material sourcing (Plate 1) and planting on the prepared land. The maturity period for cassava ranges from six to 12 months, and sometimes 18 months depending on the variety cultivated. After planting, farm management activities comprising mainly weed and pest control are undertaken periodically until the cassava is matured for harvesting. In Ghana, weed control under cassava farms is usually done through manual clearing or application of herbicides depending on availability and cost of labour. Farming households with adequate family labour usually do manual weed control using cutlasses, while those without adequate family labour usually resort to the application of herbicides.

Cassava Value Chain Activity Flow

1. **Land Preparation**
    - Land clearing
    - Tilling or ploughing
    - Ridge formation
2. **Planting**
    - Selection of disease-resistant varieties
    - Planting of cassava stem cuttings
3. **Crop Management**
    - Weed control (Manual and herbicide usage)
4. **Harvesting**
    - Manual or mechanical harvesting (usually after 6-12 months)
    - Gathering & Sorting
    - Loading
5. **Post-Harvest Handling**
    - Transportation to processing centers or markets
    - Offloading
    - Temporary storage (in sacks or heaps)
6. **Processing**
    - Peeling
    - Washing
    - Grating/Milling
    - Pressing/Fermentation
    - Frying/Roasting
    - Packaging
7. **Marketing & Distribution**
    - Local markets & District markets (Wholesalers & Retailers)
    - Export (processed products)
8. **Consumption and disposal**

Figure 1: Cassava Value Chain Stages

Typically, farmers weed two to three times before cassava is harvested. Harvested cassava roots (tubers) are usually gathered and sorted out before loading and transportation to processing centers and /or urban markets for sale. There are instances where cassava traders and processors buy the harvested tubers at the farmgate and bear the transportation costs. In many of the communities visited during the survey, the common means of transporting cassava was the tricycle/ aboboyaa (Plate 2).

Cassava tubers transported to food markets in rural communities and district markets are sold in the fresh form to wholesalers and retailers who in turn sell to individual household consumers, chop bar operators and other people who do small scale processing at home. In the study area, the bulk of harvested cassava goes to processing centers at the cottage level where cassava is mainly converted into cassava grits (gari) by women. The processing of gari involves several stages including peeling of cassava tubers, washing, milling, pressing and fermentation before roasting/frying to obtain the final product. In some of the communities visited, cassava was also processed into cassava dough (Agbelima) and cassava chips which are milled into cassava powder (Konkonte).

Plate 1: Cassava planting materials

Plate 2: Harvested Cassava tubers transported using Tricycle/Aboboyaa

Plate 3: A bag of cassava tubers in the Mampong market

Plate 4: Peeling of cassava tubers for processing in Sekyere Central

Photo Credit: Filed Enumerators /KNUST

Plate 5: Peeled cassava tubers ready for milling **Plate 6: Cassava milling plant**

Plate 7: Pressing & fermentation **Plate 8: Roasting after pressing & fermentation**

Photo Credit: Filed Enumerators /KNUST

In the processing of cassava tubers/roots to gari, the main source of fuel is firewood for the roasting and diesel for the milling of the peeled cassava. The peeling activity during cassava processing produces huge volumes of waste that is mainly used as animal feed (Plates 10-12).

Plate 10: Fresh Cassava peels

Plate 11: Dry cassava peels

Plate 12: Bagged cassava peels for sale

Plate 13: Firewood for Gari processing

Photo Credit: Filed Enumerators /KNUST

2.3 Material, Resource, and Energy Flow Mapping

Table 3 provides information on yield, productivity and land use ratios generated from the field data. The cassava yield analysis shows an average yield of about 7,546 kg/acre (18,635 kg/ha), with a median of 6,000 kg/acre. This is a little above the national average, typically ranging between 16,000 and18,000 kg/ha. However, the average yield recorded for the farmers interviewed is still below what is achieved by global leaders in cassava production such as Thailand and Vietnam where land productivity ranges from 30,000 to 40,000 kg/ha. In these countries, good agronomic practices coupled with adoption of improved varieties and efficient input combination under large scale production have led to better yield performance. The implication is that, in Ghana there is room for significant cassava productivity gains and the existence of circular economy opportunity to enhance productivity per unit land area through quality planting material selection, improved agronomic practices, better soil fertility management and efficient weed and pest control, as well as efficient harvesting techniques.

The **data** also reveal that as high as **90%** of **harvested cassava** is sold, with about **9% consumed** at **home.**

The data also reveal that as high as 90% of harvested cassava is sold, with about 9% consumed at home. This represents efficient circular material flow probably due to better aggregation, quick transportation and immediate processing to keep cassava and its derivatives moving through the economy rather than stagnating or being lost. The cassava roots (tubers) are highly perishable. Therefore, harvesting is planned carefully to coincide with market demand to ensure that losses are reduced to the barest minimum. On-farm (in soil) storage is an age-old storage method adopted by cassava farmers in Ghana to keep the crop on the farm until there is a buyer. This keeps the mature tubers safe for a relatively long period in the soil before harvesting is done when processors and traders are ready to buy.

Loss rates at farm level are relatively low (2.1%). However, considering the huge volume of cassava harvested by the sampled farmers (2 million+ kg harvested), even small percentages equate to significant absolute leakage (~44,900 kg lost). Reducing this even slightly through timely and efficient harvesting techniques could recover valuable material into the system.

Planting materials (stem cuttings) used for cassava cultivation across the surveyed communities represent only 2% of the harvest. There is an opportunity for optimizing the reuse of own stems and significantly increasing the sale and commercialization of cassava stem cuttings (planting materials) to close input loops.

Table 3: Yields, Productivity and Land-Use Ratios

Metric	Value	Units	Remarks (circular economy lens)
Average cassava yield	**7,546**	kg/acre	Calculated: 10,820,964 kg ÷ 1,434 acres. Yield is very close to national average of 8.4 tons/acre (8400kg/acre). However, given that the potential yield is about 20 tons/acre, there is scope for agronomic improvements and better input combination to optimize yields.
Median cassava yield	**6,000**	kg/acre	Reflects more typical small farm performance (less influenced by outliers).
Best farm yield (max observed)	**24,750**	kg/acre	Top farms reach high efficiency; highlights potential ceiling if practices are optimised.
Average harvested cassava per producer	**23,865**	kg/farm	Average output per farm; links to income generation potential and labour efficiency.
Average cassava planting material used	**388**	kg/farm	Cassava sticks are used for vegetative propagation; higher planting material can raise sustainability concerns if reuse is poor.
Planting material share of harvest	**1.63%**	%	Planting materials (stem cuttings) represent only 2% of harvest; optimising reuse of own stems or sale of stems could close input loops.
Percentage of cassava consumed at home	**9.0%**	% of harvest	Self-consumption of about 10% is quite reasonable, given that most farmers are subsistent producers who are now commercializing.
Percentage of cassava sold by producers	**90.3%**	% of harvest	It indicates high market orientation, which strengthens product circulation efficiency.
Farm-level loss rate	**2.1%**	% of harvest	Field losses are modest; however, leakage could be targeted with improved harvesting techniques.
Average cassava farm size	**3.1**	acres/farm	Indicates smallholder nature of operations, with implications for aggregation needs. This reflects the national picture.

Source: Generated from Field data, 2025.

Table 4 provides energy, water and labour intensity ratios. Energy use at farm level stands at approximately 0.15 MJ per kg of harvested cassava, which is moderate for smallholder systems, but transport logistics account for a major portion. This suggests that mobile processing (e.g., cassava chippers or dryers located closer to farms) could halve or better the fuel use per kg by reducing bulk transportation across longer distances. Processing energy use is a major hotspot: at approximately 17.03 MJ per kg of finished product, this is extremely high and driven almost entirely by firewood combustion for the roasting/frying process in gari processing. Firewood dependency is both a circularity weakness and a sustainability hotspot. Urgent transitions to energy-efficient ovens for gari processing could dramatically enhance environmental performance and reduce the amount of smoke that women processors are exposed to during roasting/frying.

Table 4: Energy, Water and Labour Intensity Ratios

Metric	Value	Units	Remarks (circular economy lens)
Energy use at farm per kg harvested cassava	**0.15**	MJ/kg	Based on 1,660,000 MJ ÷ 10,820,964 kg. Moderate; transport fuel dominant. Scope for shared logistics to reduce energy/kg.
Energy use at processing per kg finished product	**17.03**	MJ/kg	3,780,000 MJ ÷ 222,062 kg finished product. Very high; dominated by firewood. Critical hotspot for cleaner energy interventions.
Energy use at trading per kg cassava handled	**0.164**	MJ/kg	Based on Fuel use of ~145,505 MJ ÷ 888,000 kg of fresh cassava tubers purchased per month.
Fuel for transporting harvested cassava (diesel) per kg cassava	**0.0035**	L/kg	37,742 L ÷ 10,820,964 kg. Reasonable, but scalable fuel burden; local processing would drastically reduce needs.
Water use at farm per acre	**40.21**	L/acre	57,663 L ÷ 1,434 acres. Reflects chemical spraying water only; No irrigation in cassava production.
Water use at farm per kg harvested	**0.027**	L/kg	Low direct water footprint excluding rainfall; highlights rain-fed agriculture.
Water use at processing per kg finished product	**0.057**	L/kg	12,595 L ÷ 222,062 kg finished product. Very low compared to global norms; it suggests simple processing. ***NB: most processors have stopped washing of peeled cassava tubers before milling.***
Water use at trading per kg sold	**0.0034**	L/kg	3,000 L ÷ 888,000 kg of cassava traded per month. Very low level of water usage at this stage.
Labour input at farm per kg cassava	**0.0048**	mandays/kg	51,988 mandays ÷ 10,820,964 kg. Quite moderate; mechanisation could radically improve efficiency.
Labour input at processing per kg finished product	**0.0059**	mandays/kg	1,302 mandays ÷ 222,062 kg. Slightly higher than farm labour demand. Mechanization of some processes like peeling, pressing and roasting could improve efficiency.
Labour input at trading per kg sold	**0.0010**	mandays/kg	879 mandays ÷ 888,000 kg of cassava sold per month. Suggests trading is lighter in terms of labour usage.

Water use appears modest, partly because these are rain-fed systems and most farm water use is tied to herbicides application during weed control (57,663 L total). It is significant to note that many farmers do manual weeding which does not require water but just human labour. Contrary to our a priori expectation, the water usage at the processing node (~12,595 L/year) was significantly low (~0.057 L/kg product). The huge volume of water that processors used to wash peeled cassava tubers has reduced markedly due to a change in processing technology. Women processors have now shifted from water-heavy to water-light technology by adopting clean and better peeling strategies, making it unnecessary for peeled tubers to be washed before grating/milling. By this switch in strategy, processors have on their own taken a giant step in reducing the latent wastewater that was previously associated with gari processing.

Labour burdens remain a critical challenge for production: approximately 0.0048 man-days are spent for each kilogram of cassava produced. This means that it takes one man-day to produce and harvest 208kg of cassava. This labour-to-output ratio is very high compared to mechanised agricultural systems. For instance, labour intensity could be as low as 0.001 to 0.002 man-days to produce and harvest one kilogram of cassava (i.e. 500-1000kg per man-day) under mechanization. Transitioning from manual to semi-mechanized technology for some farm operations like planting and harvesting, under shared cooperative arrangements, could drastically reduce human labour input and increase productivity per worker, thereby improving circular productivity in the value chain.

Waste, losses and byproduct recovery ratios are presented in Table 6 below. Cassava field losses are modest at 2.1%, but because production volumes are large, they translate into approximately 44,900 kilograms of cassava wasted per crop year, a major leakage in absolute terms.

This points to the need for better harvesting techniques, timely harvest planning, and efficient field collection and aggregation innovations to recover this value into the system.

Processing efficiency of 28.3% appears low from a mass perspective: only 28.3% of raw cassava input is recovered in finished product weight, with 12.5% emerging as peels and the remainder lost primarily as water drained in the form of starch during pressing and weight reduction during roasting/frying. However, extant literature suggests that a cassava-to-gari conversion ratio of 28% is significantly high compared to the average conversion rate reported in Ghana and Nigeria which ranges from 19 to 34%, with an average of about 21.8% of fresh cassava tuber weight (Kegah and Ndjouenkeu, 2023)[3].

This conversion ratio suggests that processors in the Ashanti and Bono East regions are very efficient and may be using cassava varieties with high dry matter content.

3 Kegah and Ndjouenkeu (2023) Gari, a Cassava (Manihot esculenta Crantz) Derived Product: Review on Its Quality and Their Determinants, Journal of Food Quality, https://doi.org/10.1155/2023/7238309

Although product loss during processing (spoilage) is negligible (0.24%), there is need to valorize secondary product streams like peels and effluent (i.e. the starchy liquid that drains during pressing). Currently, 60% of cassava peels are reused as animal feed, but the remaining 40% (approximately 39,186 kilograms) is discarded or underutilized, indicating a strong circular economy opportunity to process peels into compost and livestock feed.

Table 6: Waste, Loss and Byproduct Recovery Ratios

Metric	Value	Units	Remarks (circular economy lens)
Farm-level field loss rate	**0.415**	% of harvested cassava	44,906 kg lost vs. 10,820,964 kg harvested. Very low but quite sizeable absolute volume (~45 t). Prevention could significantly enhance food supply.
Processing finished product conversion rate	**28.3**	% of raw cassava input	222,062 kg finished product ÷ 783,720 kg raw cassava. Low output yield; major mass loss primarily as water and peels.
Processing byproduct (peel) generation rate	**12.5**	% of raw cassava input	97,965 kg peels ÷ 783,720 kg input. Reflects potential circular resource if all peels valorised.
Processing product loss (spoiled/damaged)	**0.24**	% of raw input	1,877 kg loss vs. 783,720 kg input. Very low, shows effective in-process handling.
Peel reuse rate (animal feed)	**60.0**	% of peels	58,779 kg used ÷ 97,965 kg generated. Strong circular reuse, but 40% (≈39,186 kg) remains untapped.
Peel wastage rate (unutilised peels)	**40.0**	% of peels	Significant opportunity to develop compost, biogas, or processed livestock feed.
Trader market waste generation	**11,007**	kg/month	Total losses across 102 traders (~108 kg/trader/month). High volume suggests market handling improvements needed.
Trader waste rate (est.)	**1.24**	% of input cassava	(11,016 kg ÷ 888,000 kg)*100 of cassava traded. Waste as percent of volume traded is quite low.
Total quantified cassava waste across chain (excluding unknowns)	**154,835**	kg/year	Farm loss + processing loss + peels (not reused) + trader waste. Represents ~7.3% of harvest, a clear systemic leakage. ******we have to be careful here! The production is for a year, processing is for one cycle (3-7days) and trading cycle was monthly. Aggregating losses across these different activity cycles must be done carefully!!!***

Source: generated from Field data, 2025.

The herbicidal properties of the cassava effluent have been reported by some processors during the field survey. In addition, some authors (e.g. Ayodele et al, 2024[4] and Ganyam et al, 2022[5]) have also reported that cassava effluent from gari processing exhibits herbicidal properties due to its cyanogenic compounds and other phytotoxic substances. Following the application of effluent from processed bitter cassava tubers on various weeds, Ganyam et al (2022) found significant reduction in chlorophyll concentrations, particularly in broom weed, indicating impaired photosynthesis. The presence of cyanide and high sodium levels in the effluent contributed to oxidative stress, leading to plant growth inhibition. Similarly, in 2024, Ayodele and others conducted field evaluation on the use of cassava effluent for weed control in okra cultivation. Their study demonstrated that cassava effluent, when applied at specific growth stages, effectively suppresses weed growth, comparable to traditional herbicides. It is significant to note, however, that the timing and combination with other weed control measures influenced the overall efficacy. These findings generally suggest that cassava effluent from gari processing could serve as a natural herbicide, offering an eco-friendly alternative for weed management in agriculture. Therefore, a significant circular opportunity exists at the processing node of the cassava value chain with respect to peels and effluent valorization.

Market waste generated by traders amounts to 1**1,007 kilograms per month,** averaging **108 kilograms** of **waste** per **trader monthly.**

Trader waste percentage was **estimated** at only **1.24%,** which is quite low.

Market waste generated by traders amounts to 11,007 kilograms per month, averaging 108 kilograms of waste per trader monthly. Trader waste percentage was estimated at only 1.24%, which is quite low. However, given the high number of traders, the quantity of waste generated could be very significant on annual basis, suggesting great opportunity for valourization when carefully aggregated on each market day.

4 Ayodele, O. P., Udemba, I. O., Ikuenobe, C. E., & Ewansiha, S. U. (2024). Field Evaluation of Cassava Effluent, Hoe Weeding, and Pendimethalin on Weed Growth and Okra (Abelmoschus esculentus L. Moench) Performance. Moor Journal of Agricultural Research, 24(1). Retrieved from https://iart.gov.ng/moorjournal/index.php/mjar/article/view/160

5 Ganyam, M. M., Anyaegbunam, K. Z., Omeje, N. O., Atsembe, D. M., Nelson, C., Kemmeth, U. C., & Samuel, C. (2022). Bioherbicide Effect of Effluent from Processed Manihot esculentus Tubers. Asian Journal of Biology, 15(2), 14–21. https://doi.org/10.9734/ajob/2022/v15i230234

2.4 Baseline Performance Indicators

Table 7 provides results from the MFA analysis. The material flow table shows that farm production generates ~2.11 M kg cassava (from 465 farms), of which roughly 90% is sold, ~10% consumed by households, and only 2% is lost in the field. This indicates most farm harvests go through the entire value chain. Processors used 0.78 M kg raw cassava, yielding 0.22 M kg of finished products but 0.98 M kg of peels. Thus ~28% of raw weight becomes food; the rest appears as byproduct or minor losses. At the trader node of the value chain, about 98% of the cassava tubers purchased as inputs are sold, leaving less than 2% as waste and losses.

The reported waste (~11 t) and losses are low to moderate, suggesting a high level of efficiency at the trader node. Our visit to the markets showed that traders convert very small tubers and near-to-expire tubers into cassava chips and later milled into flour (Konkonte) for sale or household consumption. Some traders also reported that some livestock farmers come to the market periodically to collect cassava waste.

Table 7: Material Flow Analysis

Stage / Metric	Cassava Input (kg)	Cassava Output (kg)	Cassava Used (kg)	Cassava Sold (kg)	Cassava Lost/Waste (kg)	Notes (data source and significance)
Production (Farm)	127,714 (planting)	2,112,575 (harvest)	205,775 (consumed at home)	1,901,318	44,906 (field losses)	Input = planting material used; Output = cassava harvested (sum of all farmers); Household use and sales shown; Loss = unharvested crop. Shows farm□level flows.
Processing (Cassava Products)	783,720 (raw cassava)	222,062 (finished products)	4,262 (used as food) + 58,779 (animal feed)	(not directly reported)	1,877 (product lost) + 97,965 (peels generated)	Raw cassava input and outputs from processors. Finished product output is only ~28% of input; large byproduct (peels) and small lost fraction. Indicates yield and waste at processing.

Stage / Metric	Cassava Input (kg)	Cassava Output (kg)	Cassava Used (kg)	Cassava Sold (kg)	Cassava Lost/Waste (kg)	Notes (data source and significance)
Trading (Wholesale/ Retail)	888,000 (raw cassava)	876,993	–	876,993	11,007 (loss + waste)	Traders' input/ output ratio of 98.8% is very high. Data: monthly losses ≈3,455 kg and waste ≈7,552 kg. Waste at trader node is low to moderate, indicating that inefficiency is low at this stage of the value chain.

Source: Estimated from Field data, 2025.

Table 8 provides a summary of the LCA results. The LCA metrics reveal that farming consumes high energy (~1.66×10^6 MJ from ~46,000 L fuel) and water (~5.8×10^4 L), with a total of 150,418.2 kg CO_2eq of GHG generated. Processing consumes even more energy (~3.8×10^6 MJ from firewood and diesel) and produces large peel waste (97,965 kg). In general, processing generates high amount of GHG (494,081 kg CO_2eq) and toxic emission of about 29,565kg. Trading consumes far less energy and water, and its waste is also minimal to moderate. It generates minimal GHG (79234.2 kg CO_2eq) and toxic emissions (163kg). Land use data for processors and traders were not captured in our analysis. In summary, energy intensity and GHG emissions are highest at the processing node of the value chain (due to high quantity of firewood usage), while water use peaks at farm level during herbicide application. By far, the trader node of the cassava value chain generates minimal waste and leaves minimal footprint in terms of environmental impacts.

Processing consumes even more energy **(~3.8×10^6 MJ from firewood and diesel)** and produces large peel waste **(97,965 kg)**. In general, processing generates high amount of GHG **(494,081 kg CO_2eq)** and toxic emission of about **29,565kg.**

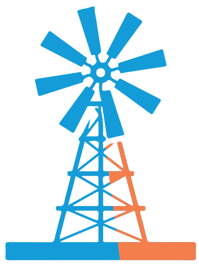


Table 8: LCA Results

Stage	Energy Use (MJ)	Water Use (L)	GHG Emissions (kg CO_2eq)	Waste (kg)	Material Input (kg)	Land Use (m^2)	Toxic Emissions (kg)	Notes
Production	~1.66×10^6 MJ	57,663	150,418.2	44,906	127,714 (planting)	5,643, 157.2	1,858	Energy from 46,065 L fuel (tractor, transport). Water for chemicals ≈57,663 L. Waste = field loss.
Process-ing	~3.78×10^6 MJ	12,595	494,080.5	97,965 (peels) + 1,877	783,720 (raw cassava)	n/a	29,565	Energy from 244,185 kg firewood + 3,190 L fuel. Major waste = peels (some used as feed). Water modest (12,595 L). Indicates high energy and byproduct generation.
Trading	~1.45×10^5 MJ	3,000	79,234.2	11,007	888,000 (raw cassava)	n/a	163	Energy from 4,043 L fuel. Traders use little water. Waste = market losses (11 t). Hotspot: transport fuel, trading loss.

Source: Field Data, 2025.

2.5 Identification of CE Hotspots

The circular-economy hotspots are presented in Table 9. The largest fuel consumption is at the farm transport stage (~37,742 L diesel), suggesting logistic optimization or local processing as CE opportunities. Processing generates nearly 100 t of cassava peels; only ~60% feed utilization, so valorizing the rest (e.g. compost, animal feed) is a clear circular opportunity. Market-level waste (~11 t) suggests valourization of waste as circular opportunity at the trading node of the value chain. Synthetic herbicide application during weed control consumes ~57,663 L water, suggesting that optimization or alternative practices or training on good herbicide application practices could reduce water usage and improve resource use efficiency.

The **largest fuel** consumption is at the farm transport stage **(~37,742 L diesel)**, suggesting logistic optimization or local processing as CE opportunities.

Table 9: Circular opportunity Hotspots

Hotspot	Key Metric / Finding	Opportunity (analysis)
Farm Transport (Producers)	~37,742 L diesel for haulage	Very high fuel use in moving cassava (from farms to markets). It suggests the need for cooperative transport or on-farm processing to reduce energy use.
Processing Byproduct (Peels & effluent)	97,965 kg peels generated	Large volume of peel waste, only ~60% used as feed. Opportunity to valorize remaining peels into compost and well packaged livestock feed in circular scheme.
	Effluent quantity 235,116 L (1kg cassava=0.3L)	Liquid (starch) could be collected during pressing and starch could be used for industrial activities and herbicide production.
Cassava Market Waste (Trading)	11,007 kg losses/ waste in markets	Traders reported minimal monthly waste; this could be huge on an annual basis. Potential for waste valourization at the marketing level presents a circular opportunity.
Water for Herbicide application (Farming)	57,663 L water for chemicals	High water for spraying herbicides. Opportunity to optimize water usage/application or shift to less water-intensive weed control methods/ practices.

The composite circular economy ratios are presented in table 10. While material retention is relatively high at 92.7%, the leakage of 7.3% (~155 t annually) is both economically and environmentally significant, particularly when embodied labour, water, energy, and land are considered lost alongside the cassava itself.

Three most urgent circular hotspots can be gleaned from the work. First relates to energy use in processing, where firewood dependency leads to extremely high energy intensity (~17 MJ/kg product), threatening forest resources and sustainable energy use. Secondly, resource stream like cassava peels (39,186 kg/processing cycle unused) represents a major missed opportunity for byproduct valorisation, either as animal feed, compost, or renewable energy feedstock (e.g., biogas). Finally, effluent (liquid starch) loss during pressing and fermentation of milled cassava at the processing node of the value chain is a candidate for valourization to produce environmentally friendly herbicide for weed control, not only in cassava production but in smallholder farming systems in general.

On the social dimension, the gender gaps in land access (men farm ~19% more land) and in cooperative participation (women 7.6 percentage points lower) suggest that circular economy interventions must also target systemic inclusion barriers, especially since women dominate downstream activities. Labour productivity improvements, especially in farming (currently only ~19.3 kg cassava per manday), are critical for releasing human energy back into higher value or diversified activities.

Table 10: Composite Circular Economy Efficiency Ratios

Metric	Value	Units	Remarks (circular economy lens)
Total material retention across chain (excluding unknown trader inflow)	**92.7**	% of initial production	Based on losses + unutilised peels = 7.3% total leakage; good baseline but considerable room for CE improvement.
Peel reuse contribution to CE closing	**60.0**	% of peels	Majority valorised into animal feed; huge scope to close the remaining 40%.
Energy input per kg of final processed cassava	**17.03**	MJ/kg	Extremely high; firewood combustion major hotspot. Clean energy transition critical.
Labour intensity per kg sold cassava (farm stage only)	**0.052**	mandays/kg	Very heavy labour burden per product unit; mechanical innovations essential.
Water footprint per kg final cassava product (processing)	**0.057**	L/kg	Low, but water reuse (e.g., recycling waste water) would still improve circularity.
Field loss recovery potential (if reduced by 50%)	**22,453**	kg/year	Recovers approx. 1% of total production; a material gain from simple harvest improvements.
Peel valorisation potential (remaining)	**39,186**	kg/year	Equivalent to approx. 17.7% of the total finished product weight, substantial new resource if captured.

Metric	Value	Units	Remarks (circular economy lens)
Trader waste recovery potential	**11,007**	kg/year	Represents about 5% of processed cassava volume; market interventions critical.
Overall circularity leakage rate	**7.3**	%	The 'lost' fraction across the value chain (waste, spoilage, unutilised byproducts).
Farm energy intensity (harvest transport)	**0.78**	MJ/kg harvested	Reasonable, but major improvements possible through transport pooling and improved logistics planning.
Processing energy intensity (final output)	**17.03**	MJ/kg finished	Alarmingly high; highest energy hotspot in the system.
Peel mass per kg raw cassava	**0.125**	kg/kg	Each kg of cassava yields ~125g of peels, a major byproduct for CE strategies.
Raw cassava input needed per kg final product	**3.53**	kg/kg	High yield by industry standards; ~28% of raw mass becomes finished goods compared to industry average of 21%.
Water intensity of farm production (chemical use)	**0.027**	L/kg harvested	Minimal, but efficiency in spraying could still improve circularity.
Water savings potential in processing (assuming 20% reuse)	**2,519**	L/year	Simple wash water recycling could save ~2,500 L annually.
Processing fuel energy share (firewood contribution)	**>95.0**	% of total energy	Overwhelming reliance on firewood; high circular risk. Efficient ovens for frying/roasting represents a great circular opportunity.
Average cassava loss per actor (producer)	**96.6**	kg/person/year	Relatively low at farm level; still meaningful in total system losses.
Average cassava loss per actor (processor)	**9.5**	kg/person/year	Very small in processing; strength to build on.
Average cassava loss per actor (trader)	**108.0**	kg/person/year	Low to moderate; an area for circular economy focus.
Ratio of trading waste to processing loss	**5.86**	–	Market waste is nearly six times higher than processing losses; shows market inefficiency hotspot.
Peel generation per processor	**495**	kg/person/cycle of processing	Each processor generates nearly half a tonne of peels per processing cycle (one week on average), untapped resource if not used.
Potential cassava feedstock for secondary use	**50,193**	kg/year	Peels + market waste; vast opportunity for biogas, animal feed or compost.
Labour productivity per manday (farming)	**19.3**	kg cassava/manday	Very low; investment in labour productivity (tools, training) urgently needed.
Labour productivity per manday (processing)	**170.5**	kg product/manday	Much higher than farm stage; shows processing is labour-efficient.

Metric	Value	Units	Remarks (circular economy lens)
Gendered land inequality ratio (male/female)	**1.19**	Ratio	Males have 19% larger landholdings; potential equity issue in resource distribution.
Gendered cooperative participation gap	**-7.6**	Percentage points	Women less involved in producer cooperatives; gap to be closed for circular project scaling.
Marketed cassava ratio (sold ÷ harvested)	**90.3**	%	~90% of production sold; inefficiency is quite low here.
Self-consumption ratio (consumed ÷ harvested)	**9.7**	%	Indicates reliance on cassava for household food security; important but locks up material from wider markets.
Energy efficiency potential (if transport fuel cut 30%)	**13,819**	MJ saved/ year	Significant emission and cost reduction potential through efficient logistics interventions.

Source: Field data, 2025.

2.6 Identification of Systemic Barriers

The key constraints at each node of the cassava value chain have been summarized in Figures 2 to 4. Results from the survey revealed that cassava producers are constrained by many factors. However, the most pressing constraints affecting many farmers include: limited knowledge about alternative uses of production waste, erratic rainfall, limited access to improved production technologies, high cost of labour and limited access to land.

Key constraints

At the processing node, the key constraints were identified as; limited knowledge about circular opportunities, limited access to improved processing technology, limited knowledge about improved processing methods and high cost of raw materials (cassava tubers and firewood).

At the trading node of the value chain, the most pressing constraints are high cost of raw material (cassava), high cost of transportation, limited knowledge about circular opportunities in the value chain and limited access to quality raw materials.

Figure 2: Constraints faced by Producers

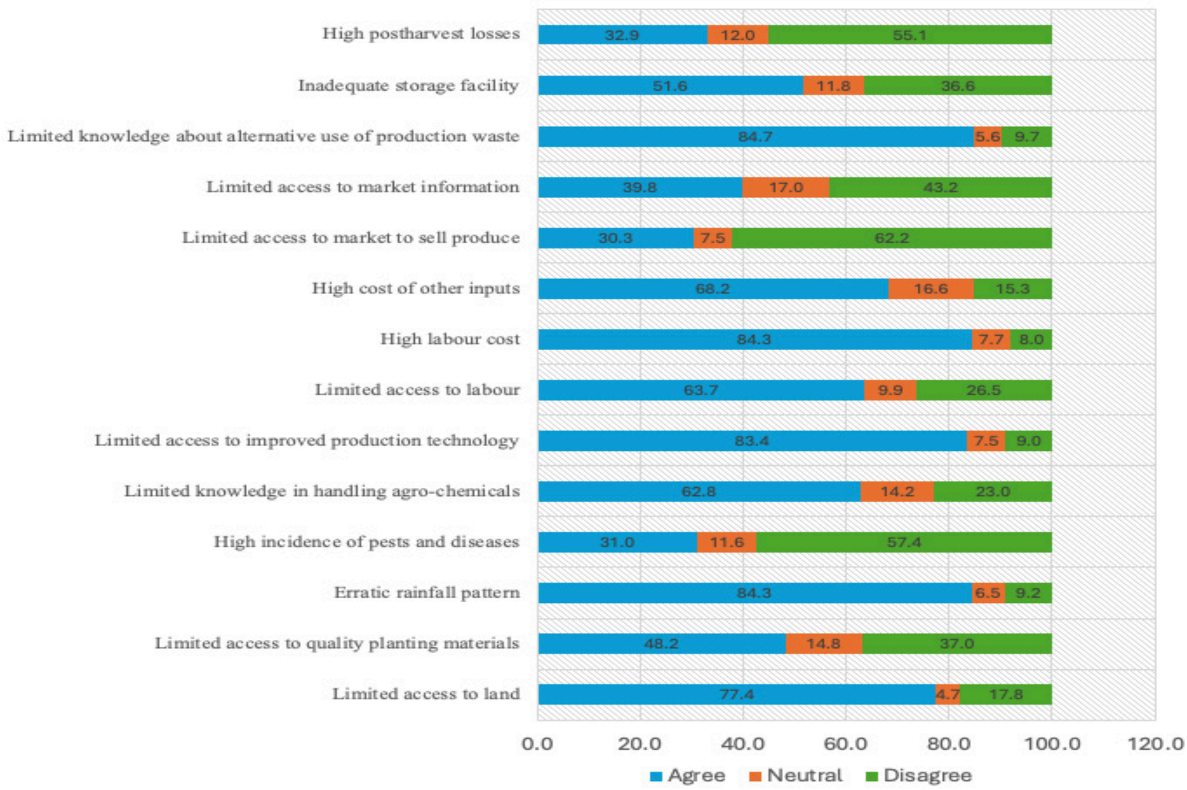


Figure 3: Constraints faced by Traders

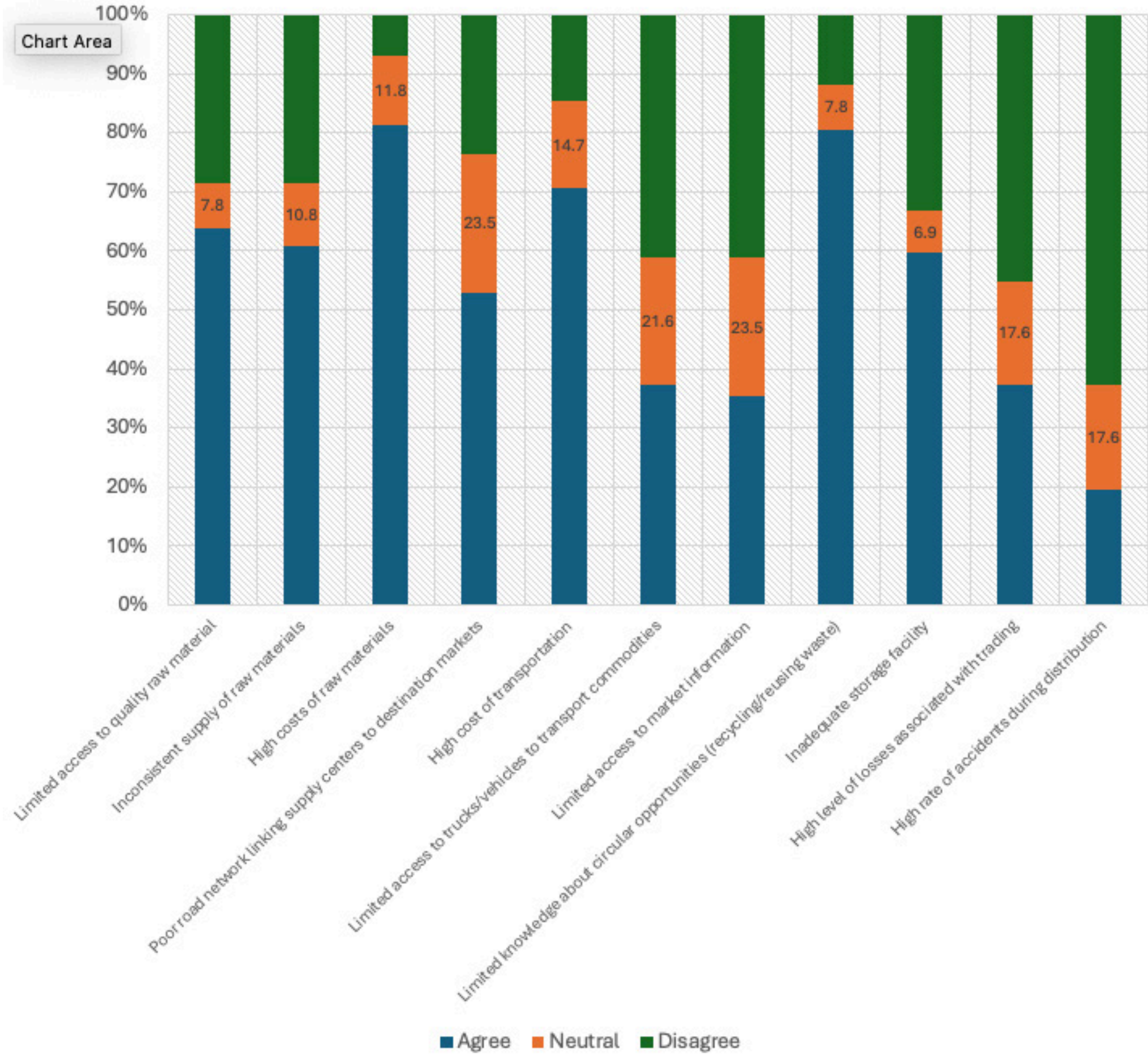
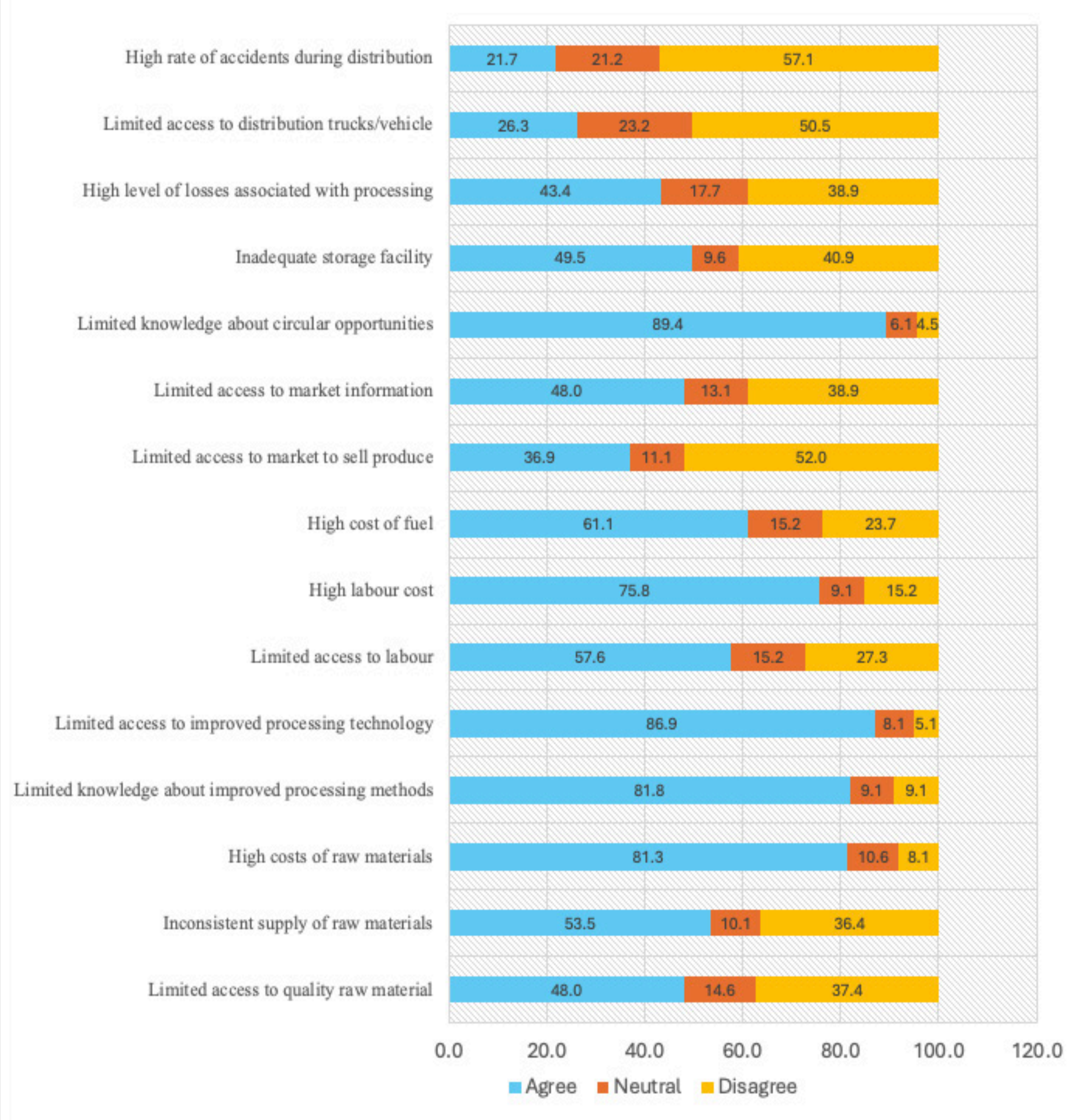


Figure 3: Constraints faced by Processors



Source: Generated from Field data, 2025.

3.0 ACTION PLAN DEVELOPMENT

The proposed action plan is presented in Table 11. The key circular opportunities identified would require several short-term, medium term and long term actions to achieve them.

Table 11: Action Plan

Phase	Time Horizon	Key Actions	Targeted Opportunities
Short-Term	1–24 months	i. Stakeholder engagement and validation of findings from the circular economy study (3 for each value chain) ii. Deepen community engagement to form value chain associations or strengthen existing ones (3 per value chain) iii. Create strategic linkages among the value chain associations at the three nodes (production, processing and marketing) to improve collaboration and promote efficiency in resource utilization. iv. Design and test circular innovations to take advantage of the circular opportunities identified and validated by stakeholders. v. -Train local artisans in the design and fabrication of circular innovations equipment/tools to address key challenges along the value chain. vi. Scale up the adoption of workable circular innovations tested. vii. Link value chain associations to financial institutions to support investment in circular innovations. viii. Capacity building for value chain association leaders and general membership (3 per value chain) ix. Develop and publish journal article (1) and policy briefs (2) based on the circular opportunity mapping study.	-Efficient utilization of energy through design and usage of efficient ovens for roasting/ frying gari. -Valourization of cassava peels into compost and animal feed. - Valourization of effluent into bio-herbicide for weed control in smallholder farming systems - Efficient logistics and transportation management to improve operational efficiency.

Phase	Time Horizon	Key Actions	Targeted Opportunities
Medium-Term	25–60 months	i. Conduct local research to test the efficacy of effluent as a bio-herbicide in smallholder farming systems. ii. Organize circular investment forum/ fair at the national level to showcase circular innovations and circular financing opportunities. iii. Establish medium to largescale waste valourization plant (firm) to in two regions (Ashanti and Bono East regions). iv. Establish a medium-to-large scale effluent valorization plant (firm) to produce bio-herbicides for smallholder farmers (in Ashanti region) v. Design and launch incentive packages for firms that recycle or resuse waste in the value chain	
Long-Term	60+ months	i. Increase peels utilization rate by 30% through valourization. ii. Reduce firewood usage in gari processing by 20% through the adoption of efficient ovens. iii. Integrate effluent-based bio-herbicide in the portfolio of weed control methods available to smallholder farmers in Ghana. iv. Increase business profitability by at least 25% following the adoption of circular innovations. v. Reduce waste by at least 25% through enhanced coordination and linkages along the agricultural and postharvest value chains in Ghana.	

4. CONCLUSION AND RECOMMENDATIONS

The section provides a summary of the study findings and key recommendations as well as next steps.

4.1 Summary of Key Findings

Based on the analysis so far, the following observations and findings were made:

- **Yield & Labour:** Median cassava yield was estimated at ~6,000 kg/acre which is comparable to a typical farmer in Ghana. The average labour productivity of ~75 kg/manday indicates high labour intensity in production, pointing to potential inefficiencies on-farm largely to labour-intensive technologies adopted at the production node of the value chain.

- **Losses & Waste:** Producers lose on average ~7% of harvest; processors lose ~4% of output and traders lose ~4–6% of the total volume handled per monthly trading cycle. These losses (due to damage, spoilage or inefficiency) represent leakage in the value chain which need to be reduced by adopting appropriate circular innovations. High volume of effluent (liquid starch) is lost during the pressing of milled cassava before roasting. This represents a huge circular opportunity for valourization.

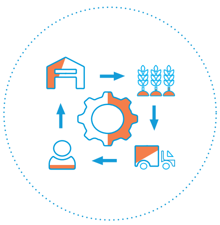
- **Byproducts:** Processors generate small byproduct amounting to ~2.6% of input weight. Study revealed that about 60% of cassava peels are reused as animal feed, leaving 40% of peels as waste which suggests a circular economy opportunity by redirecting the remaining peels to compost and professionally packaged livestock feed to close resource loops.

- **Energy & Resource Use:** Processing is relatively energy-intensive (on average ~2.7 kg firewood per kg of product). This heavy reliance on firewood (for frying/roasting) is a hotspot for circular action, where fuel-efficient ovens could be designed and deployed to cut down on fuel consumption and waste. Water usage was quite high at the farm level. However, at both processing and trading nodes of the value chain, water usage was very modest on a per-kg basis, but any savings would also bring in some circular benefits (e.g. reusing wastewater).

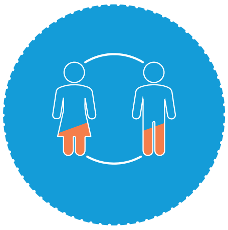
- **Transport Efficiency:** Fuel use per kg is low at ~0.04 L/kg for producers and ~0.01 L/kg for traders, but absolute farm-level fuel use was found to be quite high (mean ~132 L/farm to transport harvest). Transport inefficiencies and poor logistics planning are a circular leak (excess energy use) that improved logistics could fix. Aggregation of loads or better logistics planning could reduce per-farm fuel needs.

- **Environmental impacts:** In terms of environmental footprint, the LCA revealed that the processing node of the cassava value chain generates significantly high amount of GHG (494,081 kg CO_2eq) and toxic emissions (29,565kg) compared to the production and trading nodes.

- **Overall Circular Opportunities:** The study identified three most urgent circular hotspots. First relates to energy use in processing, where firewood dependency leads to extremely high energy intensity (~17 MJ/kg product), threatening forest resources and sustainable energy use. The second is about high volume of unused cassava peels which represents a missed opportunity for byproduct valorization in terms of animal feed, compost, or renewable energy feedstock (e.g., biogas). The third has to do with the high volume of effluent (liquid starch) that is lost during pressing and fermentation of milled cassava at the processing node of the value chain. This also presents a circular opportunity for valourization to produce environmentally friendly herbicide for weed control in smallholder farming systems in Ghana.



- **Constraints at each node of the value chain:** Among cassava producers, limited knowledge about alternative uses of production waste, erratic rainfall, limited access to improved production technologies, high cost of labour and limited access to land were identified as the key constraints. For processors, the key constraints were found to include limited knowledge about circular opportunities, limited access to improved processing technology, limited knowledge about improved processing methods and high cost of raw materials (cassava tubers and firewood). However, at the trading node of the value chain, the most pressing constraints were high cost of raw material (cassava), high cost of transportation, limited knowledge about circular opportunities in the value chain and limited access to quality raw materials.



- **Gender Balance and social capital:** While producers are evenly split by gender (~50% women), men are under-represented in processing and trading nodes of the value chain. This is quite consistent across major cassava growing regions in Ghana. The low representation of value chain actors in cooperatives shows very low social capital. This gap is a social hotspot: engaging more actors, especially women in cooperative activities will enhance social capital, leading to improved access to productive resource, extension services, financial resources, as well as training and capacity building opportunities.

4.2 Recommendations for Action

The following recommendations are made in line with the findings of the study:

i. Energy efficient ovens should be designed, tested and promoted for use by women processors in the cassava value chain to improve energy usage, reduce GHG and toxic emissions associated with cassava processing.

ii. Circular innovations leading to the valourization of cassava peels into compost and animal feed should be explored in a participatory approach with the key actors in the value chain.

iii. Circular innovations for the collection of effluent (liquid starch) during cassava processing and its valourization to produce a bio-herbicide should be explored in Ghana by local fabricators and scientists respectively.

iv. Efficient logistics arrangements for transporting farm inputs (planting materials and water for herbicide application) and harvested cassava tubers/roots should be promoted in Ghana through training and capacity building.

v. In implementing circular innovations along the cassava value chains, a gendered approach is recommended to account for the imbalance in resource endowment and access, as well are productivity differentials between males and females.

vi. The strengthening of existing cooperatives and formation of new ones in the cassava value chain is recommended to improve collaboration and social capital for operational efficiency.

4.3 Next Steps

The following outstanding activities will engage our attention in the next half year:

i. Data collection, processing and analysis of circular opportunity mapping for mango, pineapple and fish.

ii. Stakeholder analysis, engagement and validation of the findings of the circular opportunity mapping study.

iii. Design and testing of circular innovations to take advantage of the circular opportunities identified and validated by stakeholders.

iv. Scale up the adoption of workable circular innovations tested.

v. Linking value chain associations to financial institutions to support investment in circular innovations and scaling up.

vi. Development and publication of journal article and policy brief based on the circular opportunity mapping study.

APPENDICES

Appendix I: Additional Results from Data Analysis

Table A1: Summary statistics of the characteristics of Producers of Cassava

Variable	Ashanti			Bono East			Pooled sample		
	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Max-imum	Mean	Mini-mum	Maxi-mum
Household size	6.26	1	20	6.02	1	15	6.13	1	20
Number of adults in the household (>18years)	3.47	1	15	3.73	1	12	3.61	1	15
Number of women in the household	3.04	0	10	3.03	0	10	3.03	0	10
Members of Cooperative/group	42.50	5	85	36.53	1	120	38.77	1	120
Farming Experience (Years)	20.68	1	60	22.73	2	55	21.80	1	60
Experience in Cassava production (Years)	13.26	1	60	18.52	1	55	16.13	1	60
Agricultural land available to households (acres)	7.83	1	120	9.14	1	65	8.55	1	120
Cassava farm size last year (acres)	2.65	1	26	3.44	1	20	3.08	1	26
Proportion of land used for cassava production (%)	33.88			37.65			36.08		

Table A2: Summary statistics of the characteristics of Traders of Cassava

	Ashanti			Bono East			Total		
	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum
Total Household size	5.49	1	17	5.38	2	10	5.42	1	17
Number of adults in the household (>18years)	3.56	1	14	3.36	1	7	3.44	1	14
Number of women in the household	2.61	1	6	2.95	1	23	2.81	1	23
Total membership of yourcooperative/ group			60			40			60

	Ashanti			Bono East			Total		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
For how many years have you been engaged in this trading business?	14.76	1	32	11.39	1	40	12.75	1	40
Total number of workers supporting your Trading business	1.37	0	6	1.21	0	15	1.27	0	15
Number of Female workers supporting your Trading business	0.90	0	6	0.80	0	4	0.84	0	6
Number of Male workers supporting your Trading business	0.39	0	3	0.36	0	8	0.37	0	8
Number of Youth workers supporting your Trading business	0.90	0	6	1.15	0	26	1.05	0	26

Table A3: Summary statistics of the characteristics of Processors of Cassava

	Ashanti			Bono East			Pooled Sample		
Variable	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Total Household size	6.42	1	30	5.50	1	13	5.89	1	30
Number of adults in the household (>18years)	3.41	0	17	3.31	1	8	3.35	0	17
Number of women in the household	3.43	0	21	3.00	0	8	3.18	0	21
Total membership of your cooperative/ group	52.83	3	150	40.65	10	107	47.78	3	150
Experience in Cassava processing (Years)	10.03	0	83	11.05	1	48	10.62	0	83
Total number of workers supporting your processing business	5.51	0	40	7.73	0	45	6.80	0	45

Variable	Ashanti			Bono East			Pooled Sample		
	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum
Number of female workers supporting your processing business	4.55	0	30	6.60	0	45	5.74	0	45
Number of Male workers supporting your processing business	0.89	0	10	1.10	0	14	1.01	0	14
Number of Youth workers supporting your processing business	3.43	0	20	5.03	0	30	4.36	0	30
Total installed processing capacity (Mt)	6.70	0	100	7.65	0	70	7.25	0	100
Actual operational capacity of processing center (Mt)	4.37	0	90	4.90	0	38	4.68	0	90

Table A4: Cassava Production Data from Farmers

Variable	Ashanti			Bono East			Pooled Sample		
	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum
Qty of Cassava harvested per Acre (Kg)	9,947.25	120.00	24,750.00	5,550.69	225.00	24,000.00	7,545.69	120.00	24,750.00
Fuel_for_ploughing_Acre_Litres	23.33	20.00	53.33	-	-	-	23.33	20.00	53.33
Labour for Land Preparation per acre (Man-days)	6.60	1.00	20.00	4.90	1.00	17.00	5.68	1.00	20.00
Quantity of Cassava Planting Materials per Acre (Kg)	132.67	3.00	500.00	138.21	-	750.00	134.77	-	750.00
Labour_for_planting_an_acre (Mandays)	5.90	1.00	15.00	4.23	1.00	12.00	5.16	1.00	15.00
Labour_for_Weeding_an_acre (Mandays)	9.05	1.00	40.00	4.43	1.00	20.00	6.70	1.00	40.00

Variable	Ashanti			Bono East			Pooled Sample		
	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum
Labour_for_herbicide_application_on_an_acre_Mandays	2.14	1.00	8.00	2.89	1.00	6.00	2.46	1.00	8.00
Water_for_chemical_application_on_an_acre_Liters	224.44	-	1,250 .00	219.70	-	750.00	222 .44	-	1,250 .00
Labour_for_Harvesting_an_acre_Mandays	30.01	1.12	340.00	10.47	-	81.60	18.43	-	340.00
Fuel_for_Transporting_Inputs_for_an_acre_Liters	14.17	1.67	120.00	12.13	2.00	66.67	13.23	1.67	120.00
Fuel_for_Transporting_Harvested_cassava_from_an_acre_Liters	53.75	6.67	160.00	34.57	3.33	533.33	41.10	3.33	533.33
Labour_for_gathering_from_an_acre_Mandays	9.56	0.40	64.00	6.36	-	120. 00	7.46	-	120.00
Qty_of Harvested_Cassava_Lost_per_acre (Kg)	217.00	-	1,500. 00	85.54	-	600. 00	134. 19	-	1,500. 00
Qty_harvested_Cassava_sold_per_Acre (Kg)	9,345. 75	120. 00	24,000. 00	5,432. 06	150. 00	24,000. 00	7,224. 39	120. 00	24,000. 00
Proportion_of_harvested_Cassava_sold_Percent (%)	94.73	5.33	100.00	95.77	3.33	133.33	95.29	3.33	133.33
Proportion_of_harvested_Cassava_Lost_Percent (%)	2.31	-	16.13	1.75	-	13.33	1.96	-	16.13

Table A5: Cassava Trading Data from Traders

Variable	Ashanti			Bono East			Pooled Sample		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Quantity of Cassava purchased/ bought for sale monthly (Kg)	11,248.78	2,000.00	60,000.00	6,996.72	2,400.00	30,000.00	8,705.88	2,000.00	60,000.00
Quantity of Cassava sold monthly (Kg)	10,730.73	1,600.00	60,000.00	6,548.52	2,000.00	25,500.00	8,229.61	1,600.00	60,000.00
Quantity of labour for handling, loading and offloading for a monthly cycle (Mandays)	8.96	-	24.00	16.00	4.00	140.00	12.91	-	140.00
Quantity of Fuel for transporting cassava from the supply center to market for a month (Liters)	35.89	8.00	93.33	91.88	-	666.67	67.32	-	666.67
Quantity of Fuel for transporting sold cassava/ product to customers per month (liters)	21.33	5.33	40.00	40.00	13.33	80.00	29.33	5.33	80.00
Quantity of Labour for sale of cassava/ cassava product per month (Mandays)	8.00	4.00	24.00	8.00	4.00	12.00	8.00	4.00	24.00

Variable	Ashanti			Bono East			Pooled Sample		
	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum
Qty of water for trading related activities per monthly cycle (Litres)	150.00	100.00	200.00	266.67	100.00	600.00	230.77	100.00	600.00
Quantity of Cassava sold at reduced price (Kg)	343.43	60.00	1,600.00	324.00	12.00	1,000.00	333.07	12.00	1,600.00
Quantity of Cassava lost per month (Kg)	340.00	106.67	800.00	190.42	48.00	500.00	230.31	48.00	800.00
Quantity of Cassava waste generated per month (Kg)	293.33	-	528.00	340.71	64.00	1,008.00	328.35	-	1,008.00
Distance covered to bring cassava from source center (km)	15.40	-	80.00	21.82	-	180.00	19.24	-	180.00
Distance covered to deliver cassava sold to customers (km)	2.34	-	32.00	4.09	-	40.00	3.39	-	40.00
Proportion of Cassava consignment sold Monthly (%)	94.59	40.00	100.00	95.33	50.00	100.00	95.03	40.00	100.00

Table A6: Cassava Processing Data from Processors

Variable	Ashanti			Bono East			Pooled sample		
	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum
Quantity of Raw cassava processed per cycle (Kg)	3,042.89	200.00	15,000.00	4,618.78	-	22,500.00	3,958.18	-	22,500.00
Qty of Labour for peeling cassava (Mandays)	8.14	2.00	36.00	7.49	1.00	40.00	7.76	1.00	40.00
Water used during processing (Litres)	-		75			75			75
Quantity of Diesel used for milling (Litres)	14.33	12.00	16.67	17.05	6.67	33.33	16.44	6.67	33.33
Quantity of firewood used (Kg)	1,179.75	-	7,000.00	1,572.76	125.00	7,000.00	1,395.34	-	7,000.00
Qty of Labour used for Processing/frying (Mandays)	7.29	0.60	37.80	7.69	0.80	40.00	7.52	0.60	40.00
Qty of Fuel for transporting cassava tubers from source/farm to processing center (Litres)	20.62	4.00	66.67	23.72	0.20	186.67	21.99	0.20	186.67
Qty of Fuel used to transport other inputs like firewood (Litres)	9.92	3.33	26.67	13.33	6.67	26.67	10.85	3.33	26.67
Qty of Fuel for transporting Finished Product to customers (Litres)	4.00	2.00	6.67	57.17	6.67	566.67	46.88	2.00	566.67
Quantity of finished product (gari) produced (Kg)	687.98	80.00	5,000.00	1,434.43	140.00	11,340.00	1,121.53	80.00	11,340.00
Quantity of finished product lost (Kg)	23.48	-	200.00	50.41	-	280.00	38.32	-	280.00

Variable	Ashanti			Bono East			Pooled sample		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Qty of finished good discarded (Kg)				140.00	140.00	140.00	140.00	140.00	140.00
Qty of finished product sold at reduced price (Kg)	16.67	10.00	20.00	93.63	0.90	140.00	55.15	0.90	140.00
Qty of cassava peels generated (kg)	380.36	25.00	1,875.00	577.35	-	2,812.50	494.77	-	2,812.50
Qty of cassava peels used as animal feed (kg)	228.22	15.00	1,125.00	346.41	-	1,687.50	296.86	-	1,687.50

Table B1: Resource input

Stage	Fuel (L)	Water (L)	Labour (mandays)	Analysis (significance)
Production	46,065	57,663	51,988	Total diesel fuel used on farms (ploughing, transport); water for chemicals (57,663 L) and ~52,000 mandays labor. Major inputs pre-harvest, reflecting energy/labor intensity of cultivation.
Processing	3,190	12,595	1,302	Energy use mainly firewood (244,185 kg, not in table) plus 3,190 L fuel; water moderate (12,595 L); ~1,300 mandays labor. Indicates processing is labor-light but energy-heavy (wood).
Trading	4,043	3,000	879	Fuel for traders (3,837 L raw + 205 L delivery); small water use; ~880 mandays. Lower input demands than farming or processing, though waste suggests inefficiency.

Table B2: Per-actor averages

Metric	Producer (avg/person)	Processor (avg/person)	Trader (avg/person)	Analysis (per-unit impact)
Cassava harvested (kg)	~4,543	–	–	Harvest per farm respondent (2,112,575/465). Indicates producer productivity.
Cassava finished (kg)	–	~1,121	–	Finished product output per processor (222,062/198). Shows small-scale yields.
Fuel (L)	99	16	40	Average diesel per respondent: producers 46,065/465; processors 3,190/198; traders 4,043/102. Farm stage is most fuel-intensive per capita.

Metric	Producer (avg/ person)	Processor (avg/ person)	Trader (avg/ person)	Analysis (per-unit impact)
Water (L)	124	64	29	Water use per respondent (producers 57,663/465; processors 12,595/198; traders 3,000/102). Farmers use most water (chemicals).
Labour (mandays)	112	6.6	8.6	Average mandays per respondent: huge farm labor (~112), moderate in trading/ processing. Highlights labor-intensity of farming.
Cassava lost (kg)	96	9.5	108	Average loss per respondent (producers 44,906/465; processors 1,877/198; traders 11,007/102). Farm losses low; market/trade losses relatively high.

Table B3: Stage summary

Stage	% Female	Avg. Fuel Use (L/ person)	Avg. Water Use (L/ person)	Avg. Labour Input (mandays/ person)	Interpretation (circular insights)
Production	50.5%	99	124	112	Gender-balanced; highest per capita resource and labour burden. Opportunities: fuel-efficient transport, labour cooperatives, water-smart spraying.
Processing	93.4%	16	64	6.6	Predominantly female; low labour input per processor but very high wood energy use not reflected here. Circular gains possible in energy alternatives and byproduct reuse.
Trading	98.0%	40	29	8.6	Almost entirely female; moderate fuel use, low water/ labour, but significant market waste. Interventions: spoilage reduction, better packaging and storage.

Appendix II: Circular Opportunities in Cassava Value Chains reported by previous studies

Author (s)	Area of Circular Economy Utility	Key Findings
Asante, E. (2022)	Waste valorization	Wastes generated from gari production (a cassava product) can be transformed into valuable products like biogas and bioenergy, enhancing environmental sustainability.
	Minimizing environmental dependencies	Improving farming practices and utilizing local renewable energy resources can reduce the agriculture sector's environmental impact and alleviate food insecurity.
Okudoh et al. (2021)	Waste Valorization	Cassava peels can be converted into biofuels, animal feed, and bio-based materials, reducing environmental pollution and adding economic value.
	Energy Production	Utilizing cassava residues for biogas production offers a renewable energy source and mitigates waste disposal issues.
	Soil Fertility	Composting cassava waste enhances soil fertility, promoting sustainable agriculture practices.
	Industrial Applications	Extracted starch from cassava can be used in biodegradable plastics, contributing to reduced reliance on petrochemicals.
Pablo Andrés-Meza et al. (2024)	Bioenergy Production, Waste Utilization	Cassava agroindustrial co-products can be converted into high-value food and non-food products, such as bioethanol, biobutanol, biodiesel, bio-oil, and charcoal, promoting a circular economy.
	Biogas Generation	Cassava pulp can be used to generate biogas, integrating wastewater and cassava pulp in a biogas system.
Borku et al. (2025)	Cassava wastewater reuse (biogas and biosurfactants)	Cassava wastewater, once considered a pollutant, is now used for biogas production through anaerobic digestion, generating renewable energy. It also serves as a substrate for cultivating microorganisms that produce biosurfactants for industrial applications, effectively transforming waste into valuable.
	Animal feed (cassava peels, leaves, chips)	Agricultural waste from cassava processing (peels, leaves) is utilized in livestock feeding. Through fermentation, the protein content of cassava residues is significantly enhanced, turning waste into high-quality animal feed and feeding nutrients back into the agricultural production cycle.
	Natural pesticide production from processing waste	Cassava wastewater contains bioactive compounds that are used as eco-friendly pesticides, reducing reliance on chemical pesticides and closing the loop by returning processing byproducts to the farm as protective agents against pests and diseases.

Author (s)	Area of Circular Economy Utility	Key Findings
Borku et al. (2025)	Industrial product development (biodegradable plastics)	Cassava starch is used in the production of biodegradable plastics and sustainable packaging. This not only reduces synthetic plastic use but also reintegrates processing byproducts into the economy as renewable, value-added materials, contributing to a circular bioeconomy.
Borku et al.	Fermentation of cassava residues to enhance feed quality	Fermentation of cassava peels and flour residues increases their protein content (from 2.4% to 14.1%), reducing waste and providing a sustainable feed source for livestock, effectively closing the nutrient loop between crop and animal production.
Borku et al.	Cassava wastewater reuse (biogas and biosurfactants)	Cassava wastewater, once considered a pollutant, is now used for biogas production through anaerobic digestion, generating renewable energy. It also serves as a substrate for cultivating microorganisms that produce biosurfactants for industrial applications, effectively transforming waste into valuable products and closing the loop in waste management.
Borku et al.	Animal feed (cassava peels, leaves, chips)	Agricultural waste from cassava processing (peels, leaves) is utilized in livestock feeding. Through fermentation, the protein content of cassava residues is significantly enhanced, turning waste into high-quality animal feed and feeding nutrients back into the agricultural production cycle.
Borku et al.	Natural pesticide production from processing waste	Cassava wastewater contains bioactive compounds that are used as eco-friendly pesticides, reducing reliance on chemical pesticides and closing the loop by returning processing byproducts to the farm as protective agents against pests and diseases.
Marshall et al. (2023)	Agricultural waste repurposing in biomass value webs	Cassava peels are used as fertilizers to improve the yield of mushrooms and bamboo, reintegrating processing byproducts into crop and biomass production. This practice contributes to soil fertility and supports smallholder income diversification.
Casarejos et al. (2018)	Biodegradable Packaging	Cassava starch-based packaging is an alternative to petroleum-based plastics. It is compostable and can be bio-digested, returning nutrients to the soil and enabling energy recovery.
Huntrakul et al. (2020)	Edible Films for Packaging	Cassava starch films, enhanced with pea protein, can be used as biodegradable packaging. At the end of life, these films decompose naturally, reintegrating into the ecosystem without pollution.
Andreola et al. (2020)	Agro Waste for Sustainable Materials	Cassava waste can be processed into powders and used in lightweight aggregates, supporting packaging and construction applications. This reuse reduces waste and enhances material sustainability.

Author (s)	Area of Circular Economy Utility	Key Findings
Engel et al. (2019)	Starch-Based Foams for Food Storage	Cassava starch foams mixed with grape stalks degrade within seven weeks, closing the loop by eliminating long-term waste buildup and returning organic matter to the environment.
Hierro-Iglesias et al., 2022	Biorefinery for Biopolymers	Cassava waste can be used as feedstock for polyhydroxyalkanoate (PHA) bioplastics, reducing dependence on fossil-based plastics and addressing waste disposal issues. Biorefinery integration enables valorization of cassava peels, bagasse, and wastewater into bioplastics.
	Bioenergy and Biofuels	Cassava processing waste (peels, bagasse, and wastewater) can be transformed into bioethanol, biogas, and biofuel, creating a closed-loop system where waste is reintroduced into energy production.
	Organic Acid Production	Cassava waste can be processed into citric acid, lactic acid, and succinic acid through microbial fermentation, providing an alternative to synthetic chemical production and utilizing waste efficiently.
	Heat and Power Generation	Cassava stalks and processing by-products can be used for combined heat and power generation, reducing reliance on fossil fuels and lowering emissions. Waste streams from cassava processing can also be co-utilized for bioethanol and glucose syrup production.
	Fertilizer Production	Residual cassava biomass can be processed into organic fertilizers, closing the loop in agricultural waste management by returning nutrients to the soil, reducing dependency on chemical fertilizers.
Swastika et al. (2024)	Biomass utilization for bio-products and feed	Cassava peels and residues are repurposed into livestock feed, bio-based materials, and energy sources through fermentation and anaerobic digestion. This reduces waste and integrates agricultural by-products into productive cycles
	Organic fertilizer production	Cassava processing residues, such as peels and wastewater, are converted into organic fertilizers via composting and vermicomposting, returning nutrients to the soil and enhancing soil fertility
	Renewable energy production	Cassava waste is used in biogas production through anaerobic fermentation, providing an alternative energy source while reducing environmental pollution
	Industrial value chains and market development	Cassava by-products are integrated into circular supply chains to produce bio-based chemicals and biodegradable materials, creating value-added products and minimizing disposal issues

Author (s)	Area of Circular Economy Utility	Key Findings
Lilavanichakul & Yoksan	Value Chain Optimization	Cassava-based bioplastics can enhance the sustainability of the cassava value chain by reducing waste and increasing resource efficiency.
	Waste Utilization	By-products like cassava pulp and peels are used for animal feeds, compost, and biogas, promoting a circular economy.
	Economic Sustainability	Bioplastics from cassava add significant economic value, up to 14.8–22 times that of raw cassava roots, contributing to sustainable development.
	Consumer Acceptance and Market	Consumer acceptance of cassava bioplastics is moderate (48.6%), but few are willing to pay extra, indicating a need for market strategies to support circular economy practices.
	Value Chain Optimization	Cassava-based bioplastics can enhance the sustainability of the cassava value chain by reducing waste and increasing resource efficiency.
Aladegboye et al. (2022)	Infrastructure/ Construction	Cassava peels used as a sustainable binder in asphalt production, reducing reliance on petroleum-based products.
Aisien (2020)	Bioenergy	Cassava peels used for biogas production, promoting renewable energy solutions in circular agriculture.
Ospino et al. (2022)	Energy Storage	Cassava peels utilized for synthesizing activated carbon, making them cost-effective materials for energy storage devices.
Echesi et al. (2022)	Industrial Processing	Cassava peels used as substrates for pectinase production, applicable in juice extraction and textiles.
Phetrungnapha et al. (2023)	Food Waste Processing	Cassava peels applied in purification of waste cooking oil by removing free fatty acids.
Lutta et al. (2024)	Value addition & waste utilization	Emphasized the need for biorefineries to process cassava into multiple industrial products such as biofuels and biodegradable packaging materials.
Cheng et al. (2015)	Chemical and heat pretreatment for biogas yield	Chemical pretreatment achieved the highest biogas productivity (91 ± 14 mL).
Mañunga et al. (2019)	Sequential pretreatment (oyster shell-based alkalization and photocatalytic cyanide removal)	Improved biogas production by 27.6% and reduced digestate toxicity.
Versino et al. (2019)	Controlled-release fertilizers	Developed a bio-based fertilizer to improve nutrient cycling.
Andrade (2020)	Liquid hot water (LHW) pretreatment	Methane production rate and yield increased by 1.6 times and 35%, respectively.

Author (s)	Area of Circular Economy Utility	Key Findings
Mena-Durán et al. (2018)	Electrocatalysts for oxygen reduction	Used cassava residues to synthesize metal-free electrocatalysts for fuel cells.
Escaramboni et al. (2018)	Ethanol biosynthesis	Studied fast hydrolysis using amylases for bioethanol production.
Tanaka et al. (2019)	High-concentration bioethanol production	Demonstrated the feasibility of producing bioethanol from cassava stems.
Jiraprasertwong et al. (2019)	Biogas production using UASB reactor	Explored a three-stage up-flow anaerobic sludge blanket reactor for biogas production
Ianny Andrade Cruz et al.	Biogas production via anaerobic digestion (AD)	Cassava residues (peels, stems, leaves, wastewater) can be converted into biogas and biofertilizer, reducing waste accumulation and pollution.
N.M.L. Fernando et al.	Bio-Plastic Production	Cassava starch can be used to produce biodegradable bioplastics, offering a sustainable alternative to petroleum-based plastics.
.	Animal Feed	Cassava by-products like peels and bagasse can be used for livestock feed, reducing waste and enhancing resource efficiency.
	Energy Production	Cassava waste can be used for biogas production and gasification processes, supporting renewable energy generation.
	Industrial Applications	Cassava starch is used in multiple industries, including paper, textiles, pharmaceuticals, and detergents, providing value-added applications and supporting circular economy principles
Hierro-Iglesias et al. (2022)	Waste Valorization	Cassava waste (peels, bagasse, starch residues) can be transformed into bio-based products such as organic acids, ethanol, and biogas.
	Bioplastics Production	Cassava waste can be used as a feedstock for polyhydroxyalkanoates (PHA) production, reducing bioplastic costs and dependence on fossil fuels.
	Localized Biorefinery Development	Establishing processing plants near production areas reduces transport costs and enhances economic viability.
	Agricultural Waste Management	Cassava waste, if left untreated, contributes to pollution and greenhouse gas emissions, but can be valorized for biofuels and chemicals.
	Job Creation and Industrial Activity	Developing cassava-based biorefineries in Sub-Saharan Africa could create jobs and support sustainable industrial growth.
	Sustainable Feedstock for Biorefineries	Cassava waste can serve as a sustainable resource for second-generation biorefineries producing bio-based chemicals and energy.

Author (s)	Area of Circular Economy Utility	Key Findings
N.M.L. Fernando et al.	Waste Management	Cassava industrial waste can be converted into biofuels (bioethanol, biobutanol, biohydrogen, biomethane), organic acids (citric, lactic, succinic), biosurfactants, and biofertilizers through bioprocessing.
Nizzy & Kannan (2022)	Waste valorization for biofuels	Cassava waste is used to produce biofuels such as biogas, bioethanol, and biohydrogen, reducing environmental pollution.
Olukanni & Olatunji (2018)	Biogas generation from waste	Cassava waste is a potential substrate for biogas production, which can be used as a renewable energy source.
Okolie et al. (2018)	Biofertilizer production	Cassava peels and spent mushroom substrates were used to produce liquid biofertilizer, improving soil fertility.
Abel et al. (2021)	Bioplastics production	Cassava starch is used for biodegradable plastic production, though it requires plasticizers to enhance its mechanical properties.
Othman et al. (2019)	Sustainable food packaging	Cassava starch films are used for food packaging due to their biodegradability and sustainability.
Oghenejoboh et al. (2021)	Waste-to-value approaches	Cassava processing industries generate large waste volumes, which can be utilized for activated carbon and adsorbent production.
Poolprasert & Chorchong (2020)	Heavy metal adsorption	Activated carbon from cassava root effectively removes cadmium from wastewater.
Luo et al. (2021)	Pharmaceutical & wastewater treatment	Cassava waste-derived biochar was used for the adsorption of antibiotics and pharmaceuticals from water.
Dantas et al. (2017)	Organic compost and soil enhancement	Cassava wastewater was used to fertilize soil and enhance the growth of sunflower crops
Feleke et al. (2021)	Biowaste Valorization	Development of high-quality cassava peels (HQCP) for animal feed, contributing to nutrient recycling in closed-loop agriculture. However, exporting HQCP can result in nutrient loss in cassava-producing regions

Author (s)	Area of Circular Economy Utility	Key Findings
Duncan et al. (2023)	Waste valorization in livestock feed	Cassava peels, a major byproduct of cassava processing, are usually discarded or burned, causing environmental pollution. Technologies have been developed to dry cassava peels efficiently, producing "High Quality Cassava Peel" (HQCP®) meal, which serves as a nutritious alternative to maize grain in livestock feed.
	Bioenergy generation	Cassava waste effluent can be reused as a substrate for biogas production, reducing reliance on firewood and fossil fuels in cassava processing. This contributes to closing nutrient loops and improving energy sustainability.
Okike et al. (2015)	Processing innovation for feed production	Innovations for small-scale producers enable the transformation of wet cassava peels into high-quality animal feed ingredients, reducing waste and enhancing circular bioeconomy principles.
	Sustainable livestock feed	Harnessing cassava peels for livestock feed significantly reduces food waste and provides a low-cost, high-energy feed option for farmers. This approach minimizes the environmental impact of cassava processing waste.
Sekabira et al. (2022)	Organic Waste Recycling & Nutrient Loop Closure	Composting of organic waste (household, farm residues, and livestock waste) is practiced, but nutrient loops remain open due to lack of systematic recycling.
	Waste Valorization	Potential for valorization of waste into compost, biochar, and livestock feed to enhance soil fertility and reduce environmental waste.
	Consumer Perception & Adoption	Majority of consumers support circular economy practices and are open to consuming food grown using recycled organic waste, though concerns exist regarding human waste as fertilizer.
	Policy & Institutional Support	Existing policies on circular bioeconomy are insufficient and require urgent attention for proper implementation and scaling of innovations.
Osorio, Flórez-López, Grande-Tovar	Food Loss and Waste (FLW) Management	Processing peels and bagasse into animal feed, compost, or bio-based materials. Fermentation of residues for bioethanol production.

Author (s)	Area of Circular Economy Utility	Key Findings
Cruz et al. (2021)	Waste valorization and biogas production	Cassava residues (peels, stems, leaves, and wastewater) can be valorized through anaerobic digestion (AD) to produce biogas and biofertilizers, contributing to a circular economy by converting waste into renewable energy and reducing environmental pollution.
	Biorefinery approach	Cassava waste can be integrated into a biorefinery model, producing bioenergy (biogas) and bio-based products, reducing waste accumulation, and promoting resource recovery.
	Anaerobic digestion (AD)	AD of cassava wastewater and solid residues can generate biogas (methane) and digestate, which can be used as organic fertilizer, closing the loop in agricultural waste management.
	Co-digestion and pretreatment	Co-digestion of cassava residues with nitrogen-rich substrates (e.g., animal manure) improves biogas yield and balances the carbon-to-nitrogen (C/N) ratio, enhancing the efficiency of the AD process.
	Biogas and digestate applications	Biogas from cassava residues can be used for heat, electricity, or upgraded to biomethane for vehicle fuel, while digestate can serve as a nutrient-rich biofertilizer, reducing the need for chemical fertilizers.
	Challenges and future directions	Despite the potential, the adoption of biogas technology from cassava residues in Brazil faces challenges such as lack of policies, financial support, and public awareness. Future research should focus on economic feasibility and scaling up AD technologies.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Appendix III: Data Collection Instruments

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

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GHANA CIRCULAR ECONOMY PROJECT, UNIDO

CIRCULAR ECONOMY STUDY ON SELECTED AGRICULTURAL AND AGRO-PROCESSING VALUE CHAINS IN GHANA

(BASELINE & CIRCULAR OPPORTUNITIES MAPPING SURVEY)

QUESTIONNAIRE FOR PRODUCERS/FARMERS

Consent note:

My name is... I am from KNUST working on the Ghana Circular Economy Project in collaboration with UNIDO and HTU. You have been approached to help respond to some questions on your role and general operations along the agriculture & Agro-processing value chain because of your special position and activities in the chain. Any information you provide will be used solely for research purposes, and no information shared with us will be disclosed to any person or group without your prior consent or notification. While we don't promise any direct benefit to you from this interview, the findings have the potential of making a contribution to our understanding of the circular opportunities along the value chain that can be explored for enterprise development to create employment in the near future. There are no known risks associated with your participation in this research other than your time spent with us. Your participation is voluntary, and you have the right to withdraw from the interview at any point when you are not comfortable. However, your participation to the end would be very much appreciated.

Thank you.

Are you willing to participate in this study? 1. Yes|__| 2. No|__|

If YES, proceed but If NO, end survey.

Are there any questions you want to ask about the research? 1. Yes|__| 2. No|__|

If YES, please ask your question. If NO, proceed.

A. Screening / Identification Questions

No.	Question	Response
A.1	Questionnaire ID	
A.2	Name of Enumerator	

No.	Question	Response
A.3	Name of Respondent	
A.4	Contact of respondent	
A.5	Date of interview	
A.6	Starting time of interview	
A.7	Region	1. Ashanti [ ] 2. Brong [ ] 3. Bono East [ ]
A.8	District/ Municipality	1. Mampong [ ] 2. Techiman [ ] 3. Amanteng [ ] 4. Kintampo North [ ] 5. Sunyani West [ ] 6. Akuapim South [ ] 7. Ga West [ ] 8. Asuogyaman [ ] 9. Others (----- -------------------
A.9	Community	
A.10	Value chain Type	1. Cassava [ ] 2. Mango [ ] 3. Pineapple [ ] 4. Fish [ ]

SECTION 1: DEMOGRAPHIC INFORMATION

1. Sex of respondent	Female |__| Male |__|
2. Age of respondent	<36yrs|__| 36-49yrs|__| 50-60yrs|__| >60yrs|__|
3. Highest educational level	None|__| Basic|__| Secondary|__| Tertiary|__|
4. Marital status of respondent	Single, never married |__| Married |__| Separated/Divorced/widowed|__|
5. Total Household size	|__|
6. Number of adults in the household (>18years)	|__|
7. Number of women in the household	|__|______
8. Religion	Christianity|__| Islam|__| Traditionalist|__| Others (Specify) |__|...............
9. Primary occupation	Farming|__| Salaried work|__| Agro-processing|__| Trading|__| Other (Specify) |__|..................
10. Secondary occupation	Farming|__| Salaried work|__| Agro-processing|__| Trading|__| Other (Specify) |__|..................
11. Residential Status	Native|__| Non-native|__|
12.Member of Association/Cooperative	Yes|__| No|__|
13. Total membership of your cooperative/group	|__||__||__|

SECTION 2: FARM LEVEL INFORMATION

1. For how many years have you been farming .... years
2. How many years have you been producing the target commodity (Cassava/Mango/Pineapple/Fish) .... years

3. What is the total agricultural land available to your household? (Including rented or leased lands)	|_____|acres
4. What was the total agricultural land (size of pond/cage in the case of fish) used for the production of the target commodity last year?	|____| acres
5. How did you acquire the land?	Purchased|__| Family/Inherited|__| Rented/Leased|_| Gifted |_| Others|__....................................... |
6. What was the main method of land preparation?	Manual|__| Mechanical (tractor)|__|
7. What variety of the target commodity did you cultivate last year?	.... Code 1 ***(codes below the table)***
8. What was the dominant source of your planting material? ***(Single selection)***	Own farm|__| Fellow farmers|__| Agro-input dealers|__| NGO|__| FBO|__| Open market|__| Research Center [ ] Others|_..............._|

Code 1: Cassava varieties; 1=Tek Bankye 2=Capevas Bankye 3= Bankye Esam 4=Debo 5=Kuffour Bankye 6=Akosua tuntum; 7=others (Specify....)

Mango Variety; 1=Keitt 2=Kent 3=Palma 4=Others (Specify..

Pineapple Variety: 1=Sugar loaf 2=Smooth Cayenne 3=MD2 7= others (Specify..............................

Fish type grown: 1=Tilapia 2=Catfish 3=Others (Speify..

9. Production inputs

Please provide information on the inputs used for your commodity (-------------------) production last year per Acre

	Main source (codes)	**Quantity**	**Unit price (GHC)**	**Total Cost (GHC)**
Planting material/seedlings*				
Fertilizer (NPK - 50 kg)				
Fertilizer (Urea - 50 kg)				
Organic Fertilizer (FYM – Kg)				
Herbicides (liters)				
Insecticides (liters)				
Fuel for ploughing (liters)				
Fuel for transporting inputs (Litres)				

	Main source (codes)	Quantity	Unit price (GHC)	Total Cost (GHC)
Water for spraying chemicals (litres)**				
Waste associated with Planting material preparation/planting *(pieces of cassava sticks and pineapple suckers left over, black polybags holding mango seedlings removed during planting)*				
Fuel for transporting harvested produce (Litres)				
Packaging material *(e.g. sacks, plastic crates, paper, cartons, etc.)*				
Other_1:				
Others_2:				
Others_3:				

***Codes for source of planting materials & agrochemicals:** 1=own production; 2= Fellow farmers; 3=Government Agency; 4=Research Center; 5= Private nursery; 6=Agro-input shop; 7= Poultry/livestock farm; 8=Open market; 9=others_______

****Code for water sources:** 1=Rainfall; 2=Borehole; 3=stream/river; 4= Dam/small-scale irrigation scheme; 5=others_______

10. Output from production, Losses and Waste Generated

	Quantity (kg)	Unit Price (GHC)	Market Value (GHC)
Total quantity of commodity harvested			
Quantity of commodity sold			
Quantity used for own household food consumption & quantity gifted			
Quantity used for animal feed			
Quantity lost (during harvesting, gathering, loading and transportation).			
Quantity of waste/debris generated after harvest (leaves, sticks, fruits, rotten tubers, peels, etc.)			

11. Qualitative Losses

In your estimation, what proportion (%) of the **economic value (price of your commodity did you lose *because of quality deterioration*** when undertaking various value chain activities during your last year?	Proportion of Loss during **Last year** 1= 5% or less, 2= 6-10%, 3= 11-15%, 4= 16-20%, 5= 21-25% 6= 26-30%, 7= more than 30%.
Proportion/Percentage loss in value (price*) of commodity during harvesting	
Proportion/Percentage loss in value (price) of commodity during post-harvesting on-farm (i.e. during gathering and loading, etc.)	
Proportion/Percentage loss in value (price*) of commodity due to Rodents or insect attack	
Proportion/Percentage loss in value (price*) of commodity during storage	
Proportion/Percentage loss in value (price*) of commodity during processing	
Proportion/Percentage loss in value (price*) of commodity during carting/transportation	

***Use the unit price of wholesome tuber/fruit that has suffered no quality defects as the standard.**

12. Marketing Outlets

i. Indicate the main sales point of your commodity	Farm gate|__| Market within community|__| Market within district|__| Market outside the district|__| Market outside the region|__| Market outside Ghana |__|
ii. Indicate the main off-taker of your commodity	Aggregator|__| Wholesaler|__| Retailer|__| Processors/Food Vendors|__| Institutional buyers *(e.g., Hotels, schools, hospitals) |__|* *Others (Specify)* ....
iii. Average distance covered to deliver commodity (Km)	
iv. Means of transport to deliver commodity? (bicycle/motorbike/tricycle(aboboyaa)/public transport/Own truck/head carriage/others)	

v. Did you experience any challenge in finding buyers or off-takers for your commodity last year?	Yes|__| No|__|
vi. If ***"Yes"*** what was the main reason?	…………………………………………………………………………

SECTION 3: CIRCULAR OPPORTUNITIES

1. What proportion of the waste generated in your production process do you reuse or recycle back into your production process? ___%

2. In which ways do you reuse the waste?
   1. Composting/Farm Yard Manure [ ] 2. Mulching [ ] 3. Cooking fuel [ ]
   4. Animal feed [ ] 5. Others (________________________) 6. Not Applicable [ ]

3. Are there other local uses for the waste generated from your commodity? Yes [ ] No [ ]

4. If yes, in which ways are the waste products being reused currently?

5. In which other ways do you think the waste products could be reused?

6. What technologies or approaches would be required to be able to reuse/recycle the waste from your production process?

7. Describe the employment generation potential of the ways in which the waste products could be reused or recycled

8. Are there opportunities to reduce waste in your production process? Yes [ ] No [ ]

9. If yes, in which ways?

10. What technologies or approaches are required to achieve reduce waste in your production process?

11. Describe the socio-economic benefits that can be derived from reducing waste in your production process?

SECTION 4: CONSTRAINTS ANALYSIS

Please, rank each of the following constraints in the production of your commodity in order of severity *(Scale: 1=Very Low; 2=Low; 3=Quite High; 4=High; 5=Very High)*

Constraint	Rank
Limited access to land	|__|
Limited access to quality planting materials	|__|
Erratic rainfall pattern	|__|
High incidence of pests and diseases	|__|
Limited knowledge in handling agro-chemicals	|__|
Limited access to improved production technology	|__|
Limited access to labour	|__|
High labour cost	|__|
High cost of other inputs	|__|
Limited access to market to sell produce	|__|
Limited access to market information	|__|
Limited knowledge about circular opportunities	|__|
Inadequate storage facility	|__|
High postharvest losses	|__|
Others 1 (Specify)......................................	|__|
Others 2 (Specify)......................................	|__|
Others 3 (Specify)......................................	|__|

SECTION 5: OTHER ISSUES

1. Has land use change over time resulted in deforestation, soil degradation, etc? (Yes/No)

2. If yes, how has this affected your production?

3. Describe the conservation measures you have adopted to maintain soil quality

4. How would you describe the relationship between you and your input suppliers?
   1. Very weak [ ] 2. Weak [ ] 3. Quite strong [ ] 4. Strong [ ] 5. Very strong [ ]

5. Do you have any formal contract (written) with some of your input suppliers?
   Yes [ ] No [ ]

6. If yes, are contract terms respected by input suppliers? 1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ] 5. No, in all cases [ ]

7. If yes, do you respect the contract terms with your input suppliers? 1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ] 5. No, in all cases [ ]

8. Do you have any formal contract (written) with some of your offtakers?
   Yes [ ] No [ ]

9. If yes, are contract terms respected by offtakers? 1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ] 5. No, in all cases [ ]

10. If yes, do you respect the contract terms with your offtakers? 1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ] 5. No, in all cases [ ]

11. What are your main sources of finance for your production/farming business?
    1. Own funding [ ] 2. Family and friends [ ] 3. Credit from Banks [ ] 4. Credit from Cooperative Credit Union [ ] 5. Rotating Credit scheme/Susu [ ] 6. VSLA [ ] 7. Private money lender [ ] 8. Others______________________

12. Suggest three key things that you require to improve the efficiency of your operations?
    i.____
    ii. ____
    iii.____

13. Is there anything you want to tell me about your business that I have not asked about?
    ____
    ____

14. Do you have any questions for me?

    ____

    ____

End of survey

GPS location of respondent	*|__|*
Ending time of Interview	*|_hh_:_mm_:_ss_|*
End note & Appreciation	*We have come to the end of the interview.* *Thank you very much for your time and attention.*

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
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GHANA CIRCULAR ECONOMY PROJECT, UNIDO
CIRCULAR ECONOMY STUDY ON SELECTED AGRICULTURAL AND AGRO-PROCESSING VALUE CHAINS IN GHANA
(BASELINE & CIRCULAR OPPORTUNITIES MAPPING SURVEY)

QUESTIONNAIRE FOR PROCESSORS

Consent note:

My name is.. I am from KNUST working on the Ghana Circular Economy Project in collaboration with UNIDO and HTU. You have been approached to help respond to some questions on your role and general operations along the agriculture & Agro-processing value chain because of your special position and activities in the chain. Any information you provide will be used solely for research purposes, and no information shared with us will be disclosed to any person or group without your prior consent or notification. While we don't promise any direct benefit to you from this interview, the findings have the potential of making a contribution to our understanding of the circular opportunities along the value chain that can be explored for enterprise development to create employment in the near future. There are no known risks associated with your participation in this research other than your time spent with us. Your participation is voluntary, and you have the right to withdraw from the interview at any point when you are not comfortable. However, your participation to the end would be very much appreciated.

Thank you.

Are you willing to participate in this study? 1. Yes|__| 2. No|__|
If YES, proceed but If NO, end survey.

Are there any questions you want to ask about the research? 1. Yes|__| 2. No|__|
If YES, please ask your question. If NO, proceed.

A. Screening / Identification Questions

No.	Question	Response
A.1	Questionnaire ID	
A.2	Name of Enumerator	
A.3	Name of Respondent	

No.	Question	Response
A.4	Contact of respondent	
A.5	Date of interview	
A.6	Starting time of interview	
A.7	Region	1. Ashanti [ ] 2. Brong [ ] 3. Bono East [ ]
A.8	District/ Municipality	1. Mampong [ ] 2. Techiman [ ] 3. Amanteng [ ] 4. Kintampo North [ ] 5. Sunyani West [ ] 6. Akuapim South [ ] 7. Ga West [ ] 8. Asuogyaman [ ] 9. Others
A.9	Community/ Location	
A.10	Value chain Type	1. Cassava [ ] 2. Mango [ ] 3. Pineapple [ ] 4. Fish [ ]
A.11	Position in the organization	1. Owner-manager [ ] 2. Manager [ ] 3. Management staff [ ] 4. Worker [ ] 5. Other_
A.12	Type of processor	1. Home level processing [ ] 2. Cottage level processing [ ] 3. Industrial processing [ ]

SECTION 1: DEMOGRAPHIC INFORMATION

1. Sex of respondent	Female |__| Male |__|
2. Age of respondent	<36yrs|__| 36-49yrs|__| 50-60yrs|__| >60yrs|__|
3. Highest educational level	None|__| Basic|__| Secondary|__| Tertiary|__|
4. Marital status of respondent	Single, never married |__| Married |__| Separated/Divorced/widowed|__|
5. Total Household size	|__|
6. Number of adults in the household (>18years)	|__|
7. Number of women in the household	|__|______
8. Religion	Christianity|__| Islam|__| Traditionalist|__| Others *(Specify)* |__|...............
9. Primary occupation	Agro-processing|__| Farming|__| Salaried work|__| Trading|__| Other (Specify) |__|..................
10. Secondary occupation	Agro-processing|__| Farming|__| Salaried work|__| Trading|__| Other (Specify) |__|..................
11. Residential Status	Native|__| Non-native|__|
12.Member of Association/ Cooperative	Yes|__| No|__|
13. Total membership of your cooperative/group	|__||__||__|

SECTION 2: PROCESSING LEVEL INFORMATION

1. For how many years have you been engaged in this processing business? .... years

2. How many workers support your processing business? Total________; Females_________; Males_________; Youth (<36yrs)___

3. What is your total installed capacity (Mt)	|_____| Mt
4. What is your actual operational capacity (MT)?	|____| Mt
5. Which best describes the ownership structure?	Own business (sole) |__| Family business/Inherited|__| Partnership|_| Cooperative/Group ownership |_| Others|__.................................... |
6. What best describes your processing technology?	Fully Manual|__| >50% Manual [ ] >50% Mechanized [ ] Fully mechanized [ ]
7. What variety of the target commodity do you usually process?	.... Code 1 *(codes below the table)*
8. What are the dominant sources of your raw material? ***(multi-selection)***	Own farm|__| Contract producers [ ] Independent producers/ farmers|__| FBOs/Cooperatives|__| Open market|__| Others|_..................................._|
9. Final product/ intermediate product obtained from processing	Gari [ ] Starch [ ] fruit juice [ ] Dry Fruit chips [ ] Smoked fish [ ] salted fish [ ] Others______________
10. Main by-products from processing	Peels [ ] mango seeds [ ] Crowns [ ] Fish scales & intestines [ ] Waste water [ ]

Code 1: Cassava varieties; 1=Tek Bankye 2=Capevas Bankye 3= Bankye Esam 4=Debo 5=Kuffour Bankye 6=Akosua tuntum; 7=others (Specify....); **Mango Varieties;** 1=Keitt 2=Kent 3=Palma 4=Others (Specify..; **Pineapple Varieties:** 1=Sugar loaf 2=Smooth Cayenne 3=MD2 7= others (Specify..............................

Fish type processed: 1=Tilapia 2=Catfish 3=Others (Specify...

9. Processing inputs

Please provide information on the inputs used for your commodity (------------------) processing in a typical business cycle

Input	Main source (codes)	Quantity	Unit price (GHC)	Total Cost (GHC)
i. Raw materials (main commodity-cassava, fruit, fish) (Mt)*				
ii. Other raw materials (Ingredients/additives)				
iii. Water (litres)**				
Fuel (Diesel) (Litres)				
iv. Fuel (Firewood) (Mt)				
v. Fuel (Biomass or crop residue) (Mt)				
vi. Fuel (Petrol) (Litres)				
vii. Electricity (kWh)				
viii.Solar Energy used (MJ)				
ix. Fuel for transporting raw materials (fresh produce) (litres)				
x. Fuel for transporting other inputs (Litres)				
xi. Packaging material ***(Plastic bottles, gallons, etc)***				
xii. Packaging materials (***Bottles***)				
xiii.Packaging material (***others-sacks, papers, cartons, etc.)***				
xiv. Fuel for transporting packaged processed products to customers (Litres)				
xv. Waste associated with transporting, processing, packaging, and transportation *(Leftovers excluding by-products)*				
xvi. Waste in the form of by-products from the processing activities				
Other_1:				
Others_2:				
Others_3:				

***Codes for sources of Raw materials: 1=own production;** 2= Contract producers; 3=Independent farmers/ producers; 4= FBOs/Cooperatives; 5=Open market; 6=others______

****Code for water sources:** 1=Rainfall; 2=Borehole; 3=stream/river; 5=others______

10. Output from processing, Losses and Waste Generated during a typical processing cycle

Item			
a. Total quantity of finished product obtained			
b. Quantity of finished product sold			
c. Quantity of semi-finished product obtained			
d. Quantity of semi-finished product sold			
e. Quantity of finished products consumed by household members or workers & quantity gifted			
f. Quantity used for animal feed			
g. Quantity lost (during processing, packaging, loading and transportation).			
h. Quantity of waste/debris generated after processing, packaging and loading			
i. Quantity of finished goods discarded due to contamination			
j. Quantity of finished goods discarded due to expiry			
k. Quantity of finished goods sold at reduced price due to quality deterioration			
l. Quantity of semi-finished goods discarded due to contamination			
m. Quantity of semi-finished goods discarded due to expiry			
n. Quantity of semi-finished goods sold at reduced price due to quality deterioration			

11. Marketing Outlets

i. Indicate the main sales point of your commodity	Factory gate|__| Market within community|__| Market within district|__| Market outside the district|__| Market outside the region|__| Market outside Ghana |__|
ii. Indicate the main off-taker of your commodity	Distributor|__| Wholesaler|__| Retailer|__| Processors/Food Vendors|__| Institutional buyers *(e.g., Hotels, schools, hospitals)* |__| Others *(Specify)* ....
iii. Average distance covered to deliver finished product (Km)	
iv. Means of transport to deliver finished product? *(bicycle/motorbike/tricycle(aboboyaa)/public transport/Own truck/head carriage/by air/ others)*	
v. Did you experience any challenge in finding buyers or off-takers for your commodity last year?	Yes|__| No|__|
vi. If ***"Yes"*** what was the main reason?	....

SECTION 3: CIRCULAR OPPORTUNITIES

1. What proportion of the waste generated in your processing operations do you reuse or recycle back into your processing business? ___%

2. In which ways do you reuse the waste?
   1. Composting/Farm Yard Manure [ ] 2. Mulching on own farm [ ]
   3. Cooking/heating fuel [ ] 4. Animal feed [ ] 5. Others (_______________)
   6. Not Applicable [ ]

3. Are there other local uses for the waste generated from your business?
   Yes [ ] No [ ]

4. If yes, in which ways are the waste products being reused currently?

5. In which other ways do you think the waste products could be reused?

6. What technologies or approaches would be required to be able to reuse/recycle the waste from your processing business?

7. Describe the employment generation potential of the ways in which the waste products could be reused or recycled

8. Are there opportunities to reduce waste in your operations? Yes [ ] No [ ]

9. If yes, in which ways?

10. What technologies or approaches are required to reduce waste in your operations?

11. Describe the socio-economic benefits that can be derived from reducing waste in your processing business?

SECTION 4: CONSTRAINTS ANALYSIS

Please, rank each of the following constraints associated with your processing business in order of severity *(Scale: 1=Very Low; 2=Low; 3=Quite High; 4=High; 5=Very High)*

Constraint	Rank
Limited access to quality raw material	|__|
Inconsistent supply of raw materials	
High costs of raw materials	|__|
Limited knowledge in improved processing methods	|__|
Limited access to improved processing technology	|__|
Limited access to labour	|__|
High labour cost	|__|
High cost of fuel	|__|
Limited access to market to sell produce	|__|
Limited access to market information	|__|
Limited knowledge about circular opportunities	|__|
Inadequate storage facility	|__|
High level of losses associated with processing	|__|
Limited access to distribution trucks/vehicle	
High rate of accidents during distribution	|__|
Others 1 (Specify)......................................	|__|
Others 2 (Specify)......................................	|__|
Others 3 (Specify)......................................	|__|

SECTION 5: OTHER ISSUES

1. How would you describe the relationship between you and your raw material suppliers?
   1. Very weak [ ] 2. Weak [ ] 3. Quite strong [ ] 4. Strong [ ] 5. Very strong [ ]

2. Do you have any formal contract (written) with some of your raw material suppliers?
   Yes [ ] No [ ]

3. If yes, are contract terms respected by raw material suppliers? 1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ] 5. No, in all cases [ ]

4. If yes, do you respect the contract terms with your raw material suppliers?
   1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ] 5. No, in all cases [ ]

5. Do you have any formal contract (written) with some of your offtakers?
   Yes [ ] No [ ]

6. If yes, are contract terms respected by offtakers? 1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ] 5. No, in all cases [ ]

7. If yes, do you respect the contract terms with your offtakers? 1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ] 5. No, in all cases [ ]

8. What are your main sources of finance for your processing business?
   Own funding [ ] 2. Family and friends [ ] 3. Credit from Banks [ ] 4. Credit from Cooperative Credit Union [ ] 5. Rotating Credit scheme/Susu [ ] 6. VSLA [ ]
   7. Private money lender [ ] 8. Others______________________

9. Suggest three key things that you require to improve the efficiency of your operations?
   i.____
   ii. ____
   iii.____

10. Is there anything you want to tell me about your business that I have not asked about?
    ____
    ____

11. Do you have any questions for me?

____

____

End of survey

GPS location of respondent/facility	*|__|__|__|__|__|__|__|*
Ending time of Interview	*|_hh_:_mm_:_ss_|*
End note & Appreciation	*We have come to the end of the interview.* *Thank you very much for your time and attention.*

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

&

GHANA CIRCULAR ECONOMY PROJECT, UNIDO

CIRCULAR ECONOMY STUDY ON SELECTED AGRICULTURAL AND AGRO-PROCESSING VALUE CHAINS IN GHANA

(BASELINE & CIRCULAR OPPORTUNITIES MAPPING SURVEY)

QUESTIONNAIRE FOR TRADERS

Consent note:

My name is.. I am from KNUST working on the Ghana Circular Economy Project in collaboration with UNIDO and HTU. You have been approached to help respond to some questions on your role and general operations along the agriculture & Agro-processing value chain because of your special position and activities in the chain. Any information you provide will be used solely for research purposes, and no information shared with us will be disclosed to any person or group without your prior consent or notification. While we don't promise any direct benefit to you from this interview, the findings have the potential of making a contribution to our understanding of the circular opportunities along the value chain that can be explored for enterprise development to create employment in the near future. There are no known risks associated with your participation in this research other than your time spent with us. Your participation is voluntary, and you have the right to withdraw from the interview at any point when you are not comfortable. However, your participation to the end would be very much appreciated.

Thank you.

Are you willing to participate in this study? 1. Yes|__| 2. No|__|
If YES, proceed but If NO, end survey.

Are there any questions you want to ask about the research? 1. Yes|__| 2. No|__|
If YES, please ask your question. If NO, proceed.

A. Screening / Identification Questions

No.	Question	Response
A.1	Questionnaire ID	
A.2	Name of Enumerator	

No.	Question	Response
A.3	Name of Respondent	
A.4	Contact of respondent	
A.5	Date of interview	
A.6	Starting time of interview	
A.7	Region	1. Ashanti [ ] 2. Brong [ ] 3. Bono East [ ]
A.8	District/ Municipality	1. Mampong [ ] 2. Techiman [ ] 3. Amanteng [ ] 4. Kintampo North [ ] 5. Sunyani West [ ] 6. Akuapim South [ ] 7. Ga West [ ] 8. Asuogyaman [ ] 9. Others
A.9	Community/ Location	
A.10	Value chain Type	1. Cassava [ ] 2. Mango [ ] 3. Pineapple [ ] 4. Fish [ ]
A.11	Position in the organization	1. Owner-manager [ ] 2. Manager [ ] 3. Management staff [ ] 4. Worker [ ] 5. Other_
A.12	Type of Trader	1. Wholesaler [ ] 2. Retailer [ ]

SECTION 1: DEMOGRAPHIC INFORMATION

1. Sex of respondent	Female |__| Male |__|
2. Age of respondent	<36yrs|__| 36-49yrs|__| 50-60yrs|__| >60yrs|__|
3. Highest educational level	None|__| Basic|__| Secondary|__| Tertiary|__|
4. Marital status of respondent	Single, never married |__| Married |__| Separated/ Divorced/widowed|__|
5. Total Household size	|__|
6. Number of adults in the household (>18years)	|__|
7. Number of women in the household	|__|______
8. Religion	Christianity|__| Islam|__| Traditionalist|__| Others (Specify) |__|...............
9. Primary occupation	Trading|__| Agro-processing|__| Farming|__| Salaried work|__| Other (Specify) |__|..................
10. Secondary occupation	Trading|__| Agro-processing|__| Farming|__| Salaried work|__| Other (Specify) |__|..................
11. Residential Status	Native|__| Non-native|__|
12.Member of Association/ Cooperative	Yes|__| No|__|
13. Total membership of your cooperative/group	|__||__||__|

SECTION 2: TRADING LEVEL INFORMATION

1. For how many years have you been engaged in this trading business? .... years

2. How many workers support your Trading business? Total________; Females_________; Males_________; Youth (<36yrs)___

3. Which of the following best describes your typical training cycle? 1. Weekly [ ] 2. Biweekly [ ] 3. Monthly [ ] 4. Quarterly [ ] 5. Others_______________

4. What is the total quantity you usually procure in a typical business cycle (Mt)	|_____| Mt
5. What proportion of the total quantity of procured commodity are you able to sell within the business cycle (%)?	|____| %
6. Which best describes the ownership structure of your business?	Own business (sole) |__| Family business/ Inherited|__| Partnership|_| Cooperative/ Group ownership |_| Others|__....................................|
7. What variety of the target commodity do you usually sell?	.... Code 1 (codes below the table)
8. What are the dominant sources from where you procure commodity for sale? *(multi-selection)*	Own farm/processing center|__| Cottage level processing center [ ] Industrial processor [ ] Contract producers [ ] Independent producers/ farmers|__| FBOs/Cooperatives|__| Open market|__| Others|_..................................._|
9. Type/form of products you usually sell?	fresh Cassava roots/tubers [ ] Fresh fruits [ ] Gari [ ] Starch [ ] Cassava Flour [ ] fruit juice [ ] Dry Fruit chips [ ] Smoked fish [ ] salted fish [ ] fresh fish [ ] Others________________________
10. Main by-products from your trading activities	Peels [ ] rotten fruits [ ] Crowns [ ] Fish scales & intestines [ ] Waste water [ ] Others_____

Code 1: Cassava varieties; 1=Tek Bankye 2=Capevas Bankye 3= Bankye Esam 4=Debo 5=Kuffour Bankye 6=Akosua tuntum; 7=others (Specify....); **Mango Varieties**; 1=Keitt 2=Kent 3=Palma 4=Others (Specify..; **Pineapple Varieties:** 1=Sugar loaf 2=Smooth Cayenne 3=MD2 7= others (Specify..............................

Fish type processed: 1=Tilapia 2=Catfish 3=Others (Specify...

9. Trading inputs

Please provide information on the inputs used for your commodity (-------------------) trading activities in a typical business cycle

Input	Main source (codes)	Quantity	Unit price (GHC)	Total Cost (GHC)
i. Raw materials (main commodity/product traded) (e.g. cassava, fruit, fish, etc.) (Mt)*				
ii. Fuel for transporting raw materials from source center to trading point (litres)				
iii. Fuel for transporting commodity/product to Customers (Litres)				
iv. Water (litres)**				
v. Packaging material ***(Plastic bottles, gallons, etc)***				
vi. Packaging materials (***Bottles***)				
Other_1:				
Others_2:				
Others_3:				

***Codes for sources of Raw materials:** 1=own production; 2= Contract producers; 3=Independent farmers/producers;

4= FBOs/Cooperatives; 5=Open market; 6=Processor; others_______

****Code for water sources:** 1=Rainfall; 2=Borehole; 3=stream/river; 5=others_______

10. Output from Trading, Losses and Waste Generated during a typical trading cycle

Item	Quantity (kg)	Unit Price (GHC)	Market Value (GHC)
a. Total quantity of commodity sold			
b. Quantity of goods sold at reduced price due to quality deterioration			
c. Quantity lost during packaging, loading, and transportation during trading.			
d. Quantity of waste/debris generated after packaging, loading, transporting and trading *(Leftovers)*			
v. Quantity of goods discarded due to contamination			
f. Quantity of goods discarded due to expiry			

11. Marketing Outlets

i. Indicate the main sales point of your commodity	Road side|__| Market within community|__| Market within district|__| Market outside the district|__| Market outside the region|__| Market outside Ghana |__|
ii. Indicate the main off-taker of your commodity	Individual households|__| Distributor|__| Wholesaler|__| Retailer|__| Processors |__| Food Vendors|__| Institutional buyers ***(e.g., Hotels, schools, hospitals)*** |__| Others *(Specify* ....
iii. Average distance covered to deliver products (Km)	
iv. Means of transport to deliver product? (bicycle/motorbike/tricycle(aboboyaa)/public transport/Own truck/head carriage/by air/ others)	
v. Did you experience any challenge in finding buyers or off-takers for your commodity last year?	Yes|__| No|__|
vi. If ***"Yes"*** what was the main reason?	....

SECTION 3: CIRCULAR OPPORTUNITIES

1. What proportion of the waste generated in your trading operations do you reuse or recycle back into your processing business? ___%

2. In which ways do you reuse the waste?
   1. Composting/Farm Yard Manure [ ] 2. Mulching on own farm [ ] 3. Cooking/heating fuel [ ] 4. Animal feed [ ] 5. Others (________________)
   6. Not Applicable [ ]

3. Are there other local uses for the waste generated from your business?
   Yes [ ] No [ ]

4. If yes, in which ways are the waste products being reused currently?

5. In which other ways do you think the waste products could be reused?

6. What technologies or approaches would be required to be able to reuse/recycle waste from your trading business?

7. Describe the employment generation potential of the ways in which the waste products could be reused or recycled

8. Are there opportunities to reduce waste in your operations? Yes [ ] No [ ]

9. If yes, in which ways?

10. What technologies or approaches are required to reduce waste in your operations?

11. Describe the socio-economic benefits that can be derived from reducing waste in your trading business?

SECTION 4: CONSTRAINTS ANALYSIS

Please, rank each of the following constraints associated with your trading business in order of severity *(Scale: 1=Very Low; 2=Low; 3=Quite High; 4=High; 5=Very High)*

Constraint	**Rank**
Limited access to quality raw material	|__|
Inconsistent supply of raw materials	|__|
High costs of raw materials	|__|
Poor road network linking supply centers to destination markets	|__|
High cost of fuel	|__|
High cost of transportation	|__|
Limited access to trucks/vehicles to transport commodities	|__|
Limited access to market information	|__|
Limited knowledge about circular opportunities	|__|
Inadequate storage facility	|__|
High level of losses associated with trading	|__|
High rate of accidents during distribution	|__|
Others 1 (Specify)......................................	|__|
Others 2 (Specify)......................................	|__|
Others 3 (Specify)......................................	|__|

SECTION 5: OTHER ISSUES

1. How would you describe the relationship between you and your raw suppliers?
   1. Very weak [ ] 2. Weak [ ] 3. Quite strong [ ] 4. Strong [ ] 5. Very strong [ ]

2. Do you have any formal contract (written) with some of your suppliers?
   Yes [ ] No [ ]

3. If yes, are contract terms respected by suppliers? 1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ] 5. No, in all cases [ ]

4. If yes, do you respect the contract terms with your suppliers? 1. Yes, in all cases [ ]
   2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ]
   5. No, in all cases [ ]

5. Do you have any formal contract (written) with some of your offtakers?
   Yes [ ] No [ ]

6. If yes, are contract terms respected by offtakers? 1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases 4. Yes, in few cases [ ] 5. No, in all cases [ ]

7. If yes, do you respect the contract terms with your offtakers? 1. Yes, in all cases [ ] 2. Yes, in many cases [ ] 3. Yes, in some cases [ ] 4. Yes, in few cases [ ] 5. No, in all cases [ ]

8. What are your main sources of finance for your trading business?
   Own funding [ ] 2. Family and friends [ ] 3. Credit from Banks [ ] 4. Credit from Cooperative Credit Union [ ] 5. Rotating Credit scheme/Susu [ ] 6. VSLA [ ] 7. Private money lender [ ] 8. Others______________________

9. Suggest three key things that you require to improve the efficiency of your operations?
   i.____
   ii. ____
   iii.____

10. Is there anything you want to tell me about your business that I have not asked about?
   ____
   ____

11. Do you have any questions for me?

   ____

   ____

End of survey

GPS location of respondent / trading point	I__I__I__I__I__I__I__I
Ending time of Interview	*I_hh_:_mm_:_ss_I*
End note & Appreciation	*We have come to the end of the interview.* *Thank you very much for your time and attention.*

In partnership with Canada

Ghana Circular Economy Centre

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Republic of Ghana

About Ghana Circular Economy Centre

The Ghana Circular Economy Centre (GCEC) project supports Ghana's transition to a resource-efficient and inclusive circular economy by promoting innovation, strengthening policy and institutional frameworks, and building capacity across key value chains, including plastics, agriculture and agro-processing (cassava, mango, pineapple and tilapia), and textiles.

The project is implemented by the United Nations Industrial Development Organization (UNIDO) in partnership with the Ministry of Environment, Science and Technology (MEST), with funding support from Global Affairs Canada.

The GCEC serves as a national hub for knowledge generation, stakeholder engagement, and the piloting of circular solutions to advance sustainable industrial development, improve resource efficiency, and create decent jobs.

Host Institution

HO TECHNICAL UNIVERSITY

Value Chain Leads

KNUST KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

UNIVERSITY OF CAPE COAST

The Or Foundation

CAPE COAST TECHNICAL UNIVERSITY

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