



# CIRCULAR ECONOMY IN GHANA'S AGRI-FOOD VALUE CHAIN

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**A Triple Bottom Line Sustainability Assessment**

APRIL, 2021

## EXECUTIVE SUMMARY

Increasing population growth and consumption are driving global food demand, with agricultural activity expanding to keep pace. At the same time, the current agricultural system in most parts of the world is wasteful, with million tonnes of agricultural food waste generated every year. The need to create systems that seek to reduce food loss and food waste has been exacerbated by global threats such as climate change and more recently the Covid19 pandemic which led to acute shortages in food supply chains among other impacts. One of such systems is the concept of circular economy; a move from a linear economy of take, make, use and dispose to a more sustainable future where waste is eliminated by converting to a resource. An agri-food circular economy therefore is a system where processes involved in food production and consumption is designed in such a way as to reduce food loss and waste. Although there are ongoing extensive research on agri-food circular economy in other parts of the world, very little research projects have been carried out in the regions which are disproportionately affected by food security threat such as the Sub-Saharan African region.

Towards closing this research gap, the University of Sheffield, UK in partnership with two Ghana-based research institutes namely the Council for Scientific and Industrial Research Food Research Institute (CSIR-FRI) and Gold Coast Sustainability and Governance Institute (GCSGI) undertook a 12-month research on exploring circular economy in Ghana's agri-food sector. The aim of the research was to assess the triple bottom line (economic, environmental and social) sustainability assessment of the country's agri-food value chain. We believe evaluating agri-food circular economy from the triple bottom line perspective presents a more comprehensive view of potential impacts that extends the narrow view of just the economic or environmental impacts. Over the duration of the project, the activities undertaken sought to capture the three pillars of sustainability with regards to agri-food circular economy in Ghana.

This report presents a summary of the relevant findings that can be applied to support policy development on agri-food circular economy in Ghana and indeed even the wider African region. A mixed methods approach was applied which included the use of the lifecycle assessment method for quantifying environmental impacts and qualitative approaches such as the use of survey and focus group session to engage relevant stakeholders. Active engagement with a diverse and representative stakeholder group provided insightful data for our project and greater understanding of Ghana's context in relation to the agri-food value chain and circular economy. The data and analysis presented in this report provides a well-grounded evidence base for policy recommendation, industry prioritization, research and innovation direction.

The findings show that although agri-food circular economy is not widely developed in Ghana, there is a real opportunity to explore agri-food circular economy opportunities in the country evidenced by some of the projects being carried out at the CSIR Food Research Institute and initiatives by other organisations. We find the concept is not entirely new to the Ghanaian populace as majority of surveyed stakeholders and consumers were familiar with some of the related concepts or principles of circular economy, especially recycling and reusing. We conclude however that the transition of Ghana's agri-food value chain to a formidable circular economy system would require multi-stakeholder approach and investment into research and technological innovation. It is our hope the recommendations suggested in the report will lead to more development of initiatives in achieving an agri-food circular economy in Ghana.

## ACKNOWLEDGEMENT

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# Table of Contents

<b>1. INTRODUCTION.....</b>	<b>1</b>
1.1 Background.....	1
1.2 Goals and Objectives of the Project.....	2
1.3 Study and Organizational Contexts.....	3
1.4 Structure of report.....	4
<b>2. CIRCULAR ECONOMY OF AGRI-FOODS IN AFRICA: STATE OF THE ART &amp; FRAMEWORK FOR ANALYSIS .....</b>	<b>6</b>
2.1 Definition and Relevance.....	6
2.2 Agri-food Circular economy.....	7
2.3 A triple bottom line approach to CE Analysis.: A Framework for analysis.....	9
<b>3. ENVIRONMENTAL ANALYSIS OF CIRCULARIZED AGRI-FOODS.....</b>	<b>11</b>
3.1 Introduction.....	11
3.2 Environmental impacts of circularized agri-foods.....	11
3.3 Summary of impacts and policy implications.....	15
<b>4. SOCIAL ANALYSIS OF CIRCULARIZED AGRI-FOODS.....</b>	<b>17</b>
4.1 Introduction.....	17
4.2 Stakeholders' Perception of circularized agri-foods.....	17
4.3 Consumer Awareness, Perceptions and Preferences of circularized agri-foods.....	21
4.4 Summary and policy implications.....	25
<b>5. ECONOMIC ANALYSIS OF CIRCULARIZED AGRI-FOODS.....</b>	<b>26</b>
5.1 Introduction.....	26
5.2 Embodied economic impacts of circularized agri-foods.....	26
5.3 Summary of Impacts and policy implications.....	27
<b>6. CONCLUSION: A TRIPLE BOTTOM LINE VIEW OF CIRCULARIZED AGRI-FOODS.....</b>	<b>29</b>
6.1 Summary of Main Findings.....	29
6.2 Recommendations.....	31
<b>REFERENCES.....</b>	<b>32</b>



# 1. INTRODUCTION

## 1.1 Background

The Food and Agriculture Organization (FAO) estimates that nearly 1.3 billion tonnes of food are lost and wasted every year and yet approximately 805 million people worldwide were thought to be chronically undernourished with greater percentage of this figure located in Africa (Gustavsson et al, 2011). Food security threat, although a global issue is experienced at varying levels in different parts of the world as echoed in the recent annual report released on state of global food security (FAO, 2020). As global population growth rate increases, there is a need to produce more food to meet the associated growth in consumption especially in Africa, since the region is projected to contribute to half of global population growth by 2050. However, the solution to meeting projected increase in food consumption demand may not necessarily depend on increase in food production only. The current system of food production and consumption in the Africa region similar to other parts of the world follows a linear economy which is saddled with waste along the agri-food value chain. A more sustainable option therefore may be to extend the idea of a circular economy into agri-food production and consumption, thus an agri-food circular economy (CE). This approach can potentially lead to significant reductions in the amount of food loss and food waste.

Although development on agri-food circular economy is being implemented worldwide especially in Europe and China, extensive empirical evidence of the concept through research conducted and documented in the Africa region is relatively limited. Discussions around the above research gap among project partners, led to the current funded research and report that explores the concept of agri-food circular economy in an African country, specifically Ghana. Ghana is located in Sub-Saharan Africa and although classified as a developing economy, the country is seen as being on a positive development trajectory.

Ghana's agri-food sector is linked to the country's socio-economic development. At the same time problems of food waste and food loss remains a challenge. Agri-Food CE is in line with the FAO and the Government of Ghana's priority areas for country programming framework (CPF) for 2018-2022. These three priority areas are Sustainable agriculture for driving Agro-industrialization and economic growth; Sustainable natural resource management; and Resilient Livelihoods for Reduced Vulnerability and Rural Poverty (UNDSP, 2018). Considering the region is also known to be part of the worst affected areas in terms of food insecurity caused by climate change, there is an urgent need to explore how circular economy models can be used to ensure waste is eliminated or at the very least reduced significantly. There are some measures that have been encouraged as solutions in addressing food loss and waste in Ghana. However, the concept of circular economy has not been fully explored in the country's agri-food sector.



## 1.2 Goals and Objectives of the Project

1. Explore evidence of circular economy business models (CEBM) currently in Ghana's agri-food sector. Here we sought to first establish wider evidence of circular economy applications, policies or networks currently in place in Ghana, and then narrowed on the agri-food sector. This was important to establish a baseline of where the country is in the first instance and serve as a guide for further research on transitioning from linear to a circular economy.

2. Carry out a triple bottom line sustainability assessment of a chosen CEBM in comparison to linear model. A triple bottom line sustainability assessment was chosen as it covers the three pillars of sustainability, that is environmental, economic and social. Most studies on circular economy, in general focuses on the environmental and economic perspective. However we believe the social pillar of sustainability is equally important in increasing the chances of a country transitioning to a functioning agri-food circular economy. In line with this aim, the project focused extensively on activities related to the social dimension of sustainability.

3. Identify the enablers and barriers of circular economy policy development in Ghana's Agri-Food sector. Workshops were organised to engage stakeholders where focus group sessions were used to lead discussions on how circular economy agenda can make its way to national policy agenda in Ghana's agri-Food sector. Policy agenda setting for CE in Ghana requires evidence base research that informs better decision making and therefore the results of the project would potentially serve as an important source of reference in this regard.

4. Identify and recommend further areas of opportunities that can be developed in expanding CEBM in Ghana's agri-food sector. The current project was meant to serve as first of a series of related research projects that would seek to contribute to efforts in transitioning Ghana and even by extension, the wider Africa region towards agri-food circular economy. Based on the project activities and findings presented in the report, recommendations were made on CEBM opportunities that can further be explored through research and innovation.

### 1.3 Study & Organizational Contexts

The lead research institution where most project activities took place was the Food Research Institute. The Food Research Institute (FRI) is the leading government research institute for food research in Ghana and is a part of the 13-member Research Institutes under the Council for Scientific and Industrial Research (CSIR). CSIR is the foremost public science and technology research institution in Ghana. The CSIR explores the use of science and technology for socio-economic development in critical areas of agriculture, industry, environment as well as some aspects of public health and social sciences.

Some institutes in CSIR promote dissemination of research findings on food production and consumption, commercialization of research results, and provides scientific advice to the Government through the Ministry of Environment Science Technology and Innovation (MESTI). To promote agri-business, Some of the agricultural based institutes in CSIR engages in animal, aquaculture and food crop production, product development and food processing, local equipment fabrication and technology business incubation. They also engage with agri-food value chain actors including farmland owners, input suppliers, farmers, and distributors/marketers. CSIR-FRI in particular, has facilities designated for processing of a number of agri-food crops including root and tubers, cereals, grains and legumes, fish, meat and dairy products as well as fruits and vegetables. From these agri-food food crops, CSIR-FRI has developed and commercialized different products. (See Figure A & B in



A CSIR-Food Research Institute workshop engaging with students on how they produce mushroom from sawdust

section 5) Research Institutes under CSIR
Food Research Institute (FRI)
Crop Research Institute(CRI)
Animal Research Institute (ARI)
Forestry Research Institute of Ghana (FORIG)
Building and Road Research Institute (BRRI)
Institute of Industrial Research(IIR)
Oil Palm Research Institute (OPRI)
Plant Genetic Resources Research Institute(PGRRI)
Savanna Agricultural Research Institute(SARI)
Science & Technology Policy Research Institute (STEPRI)
Soil Research Institute (SRI)
Water Research Institute (WRI)
Institute for Scientific & technological Information (INSTI)



CSIR- Food Research Institute Ethanol and Glucose production plant at Pokuase

## 1.4 Structure of the report

The Food Research Institute and indeed the broader CSIR engages in a number of agri-food circular economy initiatives, a few of which is listed below:

- Extraction and reformulation of herbal products for pharmaceutical use
- Converting industrial and domestic human sewage to manure and gas
- Waste such as saw dust and crop peels currently used for mushroom production at CSIR-FRI.
- Glucose and Ethanol production from High Quality Cassava Flour (HQCF).

This introductory section of the report has provided a background of the project, highlighting the goals and objectives that the project sought to achieve. The remaining sessions of the report is structured into five sections. Section 2 presents discussions on circular economy in agri-foods in Africa and highlights the framework for analysis used in the project. The next three sections (section 3, 4 & 5) is focused on presenting some key findings and discussions on environmental , social and economic sustainability analysis. Finally, the report concludes with discussions and recommendations for achieving a triple bottom line agri-food circular economy in Ghana.



# 2. CIRCULAR ECONOMY OF AGRI-FOODS IN AFRICA: STATE-OF-THE-ART & FRAMEWORK FOR ANALYSIS

## 2.1 Definition and Relevance

The concept of circular economy has several but similar definitions. The Ellen Macarthy foundation (2013), defines Circular economy as a shift from take-make-dispose to reuse and repair. Circular economy looks at finding innovative ways of reducing waste along the value chain and finding ways of managing and reusing the waste that is still inevitably created as a result of production and consumption activities. It may involve the cyclical design of products from the initial stages of production to make it easy to reuse and not throw away (Elia et al, 2017). Circular economy relies mainly on the ability to innovate and aims to design products that reduce inputs while increasing value. All this must be done while minimizing negative economic, social and environmental impacts. The main idea behind circular economy is that by the time a product is 'discarded', it has been used, repaired and reused. (Elia et al., 2017; Del-Borghi et al, 2020).

Sauvé et al. (2016), defined circular economy as closing the loop between production and consumption. This is done with a conscious effort to incorporate social and environmental considerations. The authors view circular economy as reducing raw materials and waste along all the stages of the product life cycle. According to Preston (2012), "circular economy is an approach that would transform the function of resources in the economy". This means that waste from one factory will become raw materials for another process within the same factory or another. This definition of circular economy relates to conversion of waste to resource. In a similar vein, within a circular economy system, waste resources which are outputs at one end, during the end of a product's lifecycle can be converted into consumable products. Mitchell (2015) expands the definition of circular economy to include using a resource for as long as it is still functioning to get the optimum value out of it before throwing away. This means that an item should be used till it is fully depreciated before throwing away or reusing if possible. The different definitions of circular economy are all underlined by six principles which are Reduce, Refuse, Rethink, Repair, Recycle, Reuse.



### Principles of Circular Economy

**Reduce:** This principle represents the efficient use of resources which is safe for the environment (Simone et al, 2000). The aim is to produce more but with less impact on the environment.

**Reuse:** Reuse is where the product itself is designed in such a way that it can easily be used again. It promotes a cyclical sequence of closing the loop of production (Ghisellini et al, 2016).

**Refuse:** This refers to the refusal of consumers to buy products that are not designed sustainably (Boon, E. K., & Anuga, S. W. 2020)

**Rethink:** Rethink refers to the reconsidering of current practices and lifestyle on how products are designed and manufactured (Boon, E. K., & Anuga, S. W., 2020)

**Repair:** This means fixing or restoring a product and lengthening its lifespan instead of throwing away (Boon, E. K., & Anuga, S. W.,2020)

**Recycle:** This is where the product is reproduced into a material in the original supply chain or for a different purpose (Ghisellini et al. 2016)

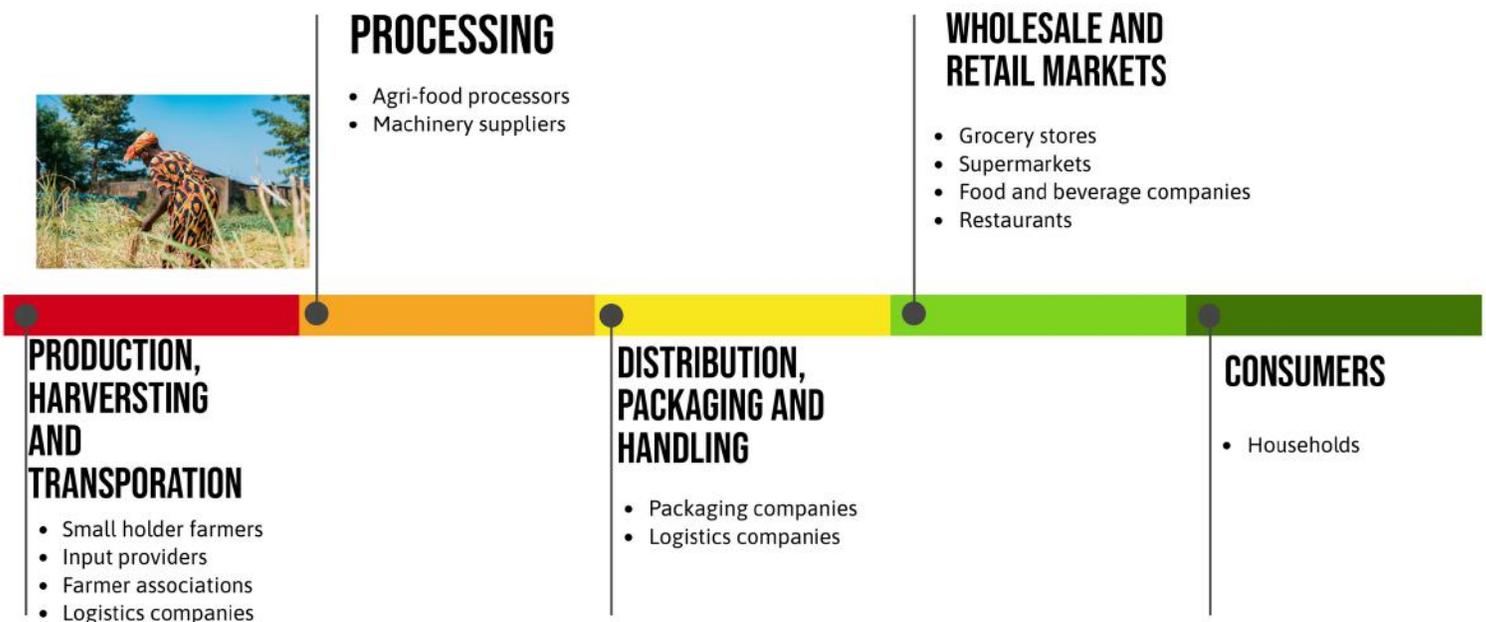
Adapted from Boon and Anuga,2020

## 2.2 Agri-food Circular Economy

Circular economy in the Agrifood chain looks at reducing the inputs of production in agriculture (input use such as water, fertiliser, etc.) and finding more efficient ways of producing with less. In addition, it also relates to the reuse of waste from farming processes such as post-harvest produce that go bad (Borghi et al, 2019). The aim is to create sustainable production and consumption patterns in the agrifood value chain in order to preserve the environment, increase market competitiveness and promote social wellbeing of people (Borghi et al., 2020; European commission, 2008). For example, a study of four UK manufacturing companies for their circularity showed that a citrus company could use the damaged oranges and lemons for cosmetics since the consumer market would not buy it (Garcia-Garcia et al, 2019). This damaged citrus would otherwise have ended up in a landfill. Other example include using of food waste for fertilizer, as biogas for producing electricity amongst others. Circular economy in the agrifood chain therefore looks at all the waste generated along the chain from raw material usage to processing to packaging to end of life to ascertain how the waste can either be reduced or reused into the same chain or into a different chain (Kibler et al., 2018).

A typical agri-food supply chain involves series of activities before the processed food product reaches end users or consumers. These activities includes production, harvesting, processing, packaging distribution, and wholesale and retail marketing. Food loss and food waste can occur along these different activities and therefore an agri-food circular economy will require efforts from stakeholders involved within the supply chain.

### Agri-Food Supply Chain and Stakeholders



## Circular Economy applications in Agri-Foods

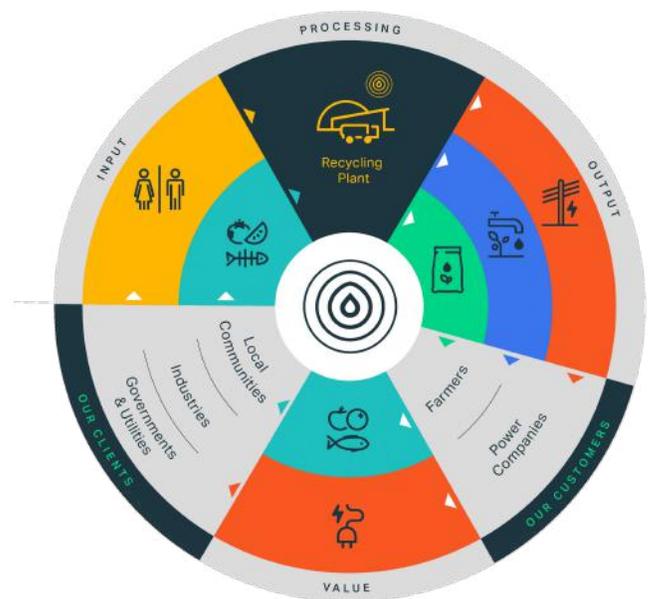
Circular economy in agrifood and other industries is in its infant stage in Africa. Deputy Director for the UN Environment Programme, confirmed the relevance of circular economy to developing countries at the World Circular Economy Forum in June 2017. Fortunately, although in its infant stage, circular economy principles are already widespread in developing countries. Countries such as South Africa, Rwanda, and Ghana amongst others have started putting in measures to circularize their countries (Murray et al, 2017).

In Ghana, CSIR is leading efforts on research and initiatives aimed at transitioning Ghana's agri-food sector to a circularized one. Some examples of their operations include mushroom production from sawdust and crop peel waste, extraction and reformulation of herbal products for pharmaceutical use, biodegradable compost bag made from oysters and converting industrial and domestic human sewage to manure and gas. However, there are more efforts needed to expand these initiatives.

A recent report by the Africa Circular Economy Network (ACEN) showcased 26 case studies of circular economy initiatives in Africa. Example of the case studies in Ghana included the following:

- **Safisana Ghana** : Designs and operates systems that take market waste and sewage to produce electricity, compost, irrigation water and seedlings.
- **Jekora Ventures**: Food waste from hospitality businesses to compost.
- **FibreWealth**: Production of multipurpose growing medium made from coconut husk.
- **Green Africa Youth Organisation**: Community-led circular economy waste management.

### Safisana Ghana Circular Economy Model



Source: Safisana Ghana

## 2.3 A Triple Bottom Line Approach to CE Analysis: A Framework for Analysis

There are different approaches that has been used in analysis of circular economy in different regions or countries. However most of these studies can be seen as addressing or highlighting benefits of circular economy from at least one of the three pillars of sustainability, that is either social, environmental or economic. In this study we adopt a triple bottom line approach where all the three sustainability are assessed.

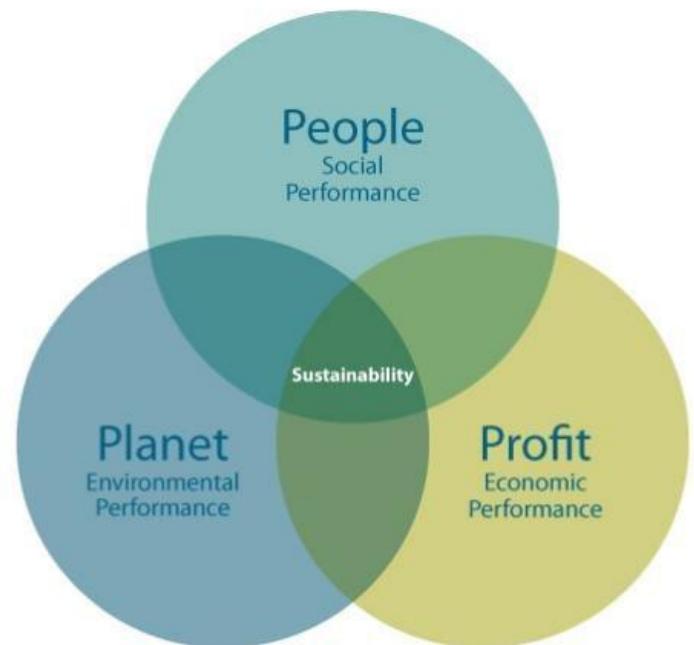
### Potential benefits of a triple bottom line Analysis of Agri-Foods

**Economic:** There is a vast economic benefit under the circular economy paradigm. Circular economy is poised to promote economic growth at the macro and micro level. This will be achieved through creating of new business models, allowing potential reduction in new extraction of raw materials since waste will now become a secondary material for production. (Del Borghi et al, 2020). Furthermore, circular economy will also enable countries to reduce reliance on imports as waste along the agrifood chain will be reduced. At the micro level, businesses will thrive as enterprises will try new business models under the circular. Research done on business using Circular economy models show that it can be profitable when done efficiently and economically. (Boon & Anuga, 2020; Ascianto et al, 2019; Bekchanov, & Mirzabaev, 2018).

**Social:** When different uses are found for waste which would have otherwise gone to the landfill, it means that new jobs will be created for the new value that is being created. Various business models designed and assessed on the basis of circular economy have shown increase in jobs moving from linear economy to circular economy. (Morgan & Mitchell, 2015; Wijkman & Skånberg, 2015; Bastein et al., 2013). One crucial element in this however, is the role that society plays in terms of their awareness, perception and openness to innovations from circular economy business models (CEBM). It is therefore important that analysis of CEBM captures the social context within which such models can thrive.

**Environmental Protection:** The reuse and management of waste ensures that the environment is not degraded by various waste which cannot be managed. Waste which would have been burnt in landfills or pushed into water bodies polluting the land and air and water will now be converted into useful resources. Environmental assessment studies conducted in various research showed positive results in the environmental assessment analysis (Aranda et al, 2019, Pomponi & Moncaster 2017; Ruiz-Real et al., 2018). In addition, food waste is for example used as fertilizer which goes back to nourish the agricultural land and also less water and other resources are used under the circular economy paradigm.

Overall, adopting a triple bottom line analysis of a circular economy system, highlights the potential impacts on people (social), planet (environment) and profits (economy); in what is commonly referred to as the 3 Ps.



Source: Coşkun Arslan and Kısacık, H., 2017



## 3. ENVIRONMENTAL ANALYSIS OF CIRCULARIZED AGRI-FOODS

### 3.1 Introduction

Throughout the literature on circular economy, its benefits in terms of environmental sustainability has received much attention. Designing a system where waste is eliminated could lead to reduced environmental impacts. For example, in a circularized system less raw materials are extracted for new production and therefore less environmental pressure. In the same way, the implementation of agri-food circular economy is expected to lead to some environmental sustainability gains in food production and consumption. These gains may involve reduction in food loss which occurs at the food production, processing and distribution stage or reduction in food waste which mainly occurs at the food consumption stage. In order to establish a move towards circularized system of production, it is important to first estimate the environmental impact associated with the linear system currently in place.

This section of the report presents findings from the environmental impact assessment specifically, embodied resources and life cycle impacts associated with processing of CSIR-FRI agri-food products. The reason why embodied resources are included is to emphasize the fact that, any waste generated during agri-food processing also translates into waste of the resources which were included (embodied) in the raw material extraction as well. In addition, we also highlight environmental impacts such as greenhouse emissions, and water depletion using the lifecycle assessment (LCA).

### 3.2 Environmental impact of circularized agri-food products

The environmental analysis conducted was based on CSIR-FRI processed agri-food products. The Institute has several agri-food products produced from different crop groups including roots and tubers, fruit and vegetables, cereals, grains and legumes.



# PRODUCTION STEPS

Summary of main steps involved in production of most agri-food crop products at FRI



## STEP 1

...

Food crops sourced from farm



## STEP 2

...

Processing



## STEP 3

...

Re-use of some crop food waste



## STEP 4

...

Non-used waste sent to landfill

### Embodied resources



### Lifecycle Impacts



### Circular Economy



### Opportunity for Circular Economy



### STEP 1-Food crops from farm

Food crops sourced are produced on croplands and therefore

have embodied resources including:

- ✓ Fertiliser embodied in crop production
- ✓ Embodied water used in irrigation
- ✓ Embodied manure used for crop protection

### STEP 2-Processing

Lifecycle impacts associated with step 2 include

- ✓ Greenhouse gas emissions (climate change impact)
- ✓ Cumulative energy demand
- ✓ Water depletion
- ✓ Landfill bulk waste

### STEP 3-Reuse of waste

Circular economy models incorporated at this stage include:

- ✓ Yam and cassava peels used for producing edible mushroom
- ✓ Compost bags (biodegradable)
- ✓ Ethanol production

### STEP 4- Non-used waste

The production system at FRI is not fully circularized as some waste are sent to the land fill or incinerator

There may be opportunities to explore circular economy models for these agro-food waste before ending up at landfill

## Embodied Environmental Impacts of Circularized Agri-Foods

Embodied resources here is used to refer to the resources that goes into the production of agri-crop (maize, yam, plantain, etc) at the farm level. The relevance of this indicator is that it highlights the amount of lost resources if these crops were not purchased for food processing at CSIR-FRI. The implication here is that if agri-food processing facilities like that of CSIR-FRI were not absorbing the various crops produced and harvested and these were to go waste on the farm, then it means the embodied resources are wasted alongside with this. The embodied resources therefore signifies the environmental cost of food loss within the agri-food crop production in the absence of a circular economy system in place.

Based data on the annual production volume of CSIR-FRI agri-food products and data from Ecoinvent version 3.6\*, we estimate four embodied resources

- Fertilisers
- Water
- Manure
- Packaging for fertilisers

We found that 12,000 tonnes of water is embodied in the production of the crops used in agri-food products at CSIR-FRI. Implying that if these ended up as post-harvest loss, all this embodied water is 'wasted' alongside. With regards to fertilisers and manure used for increasing crop yields and soil fertility, approximately 0.5 tonnes and 0.4 tonnes respectively is embodied or used in the crop production. All these resources come at a cost, (water used for irrigation, buying fertilizers, etc) and therefore the work of agri-food processing facilities is vital in eliminating food loss and working towards an agri-food circular economy.

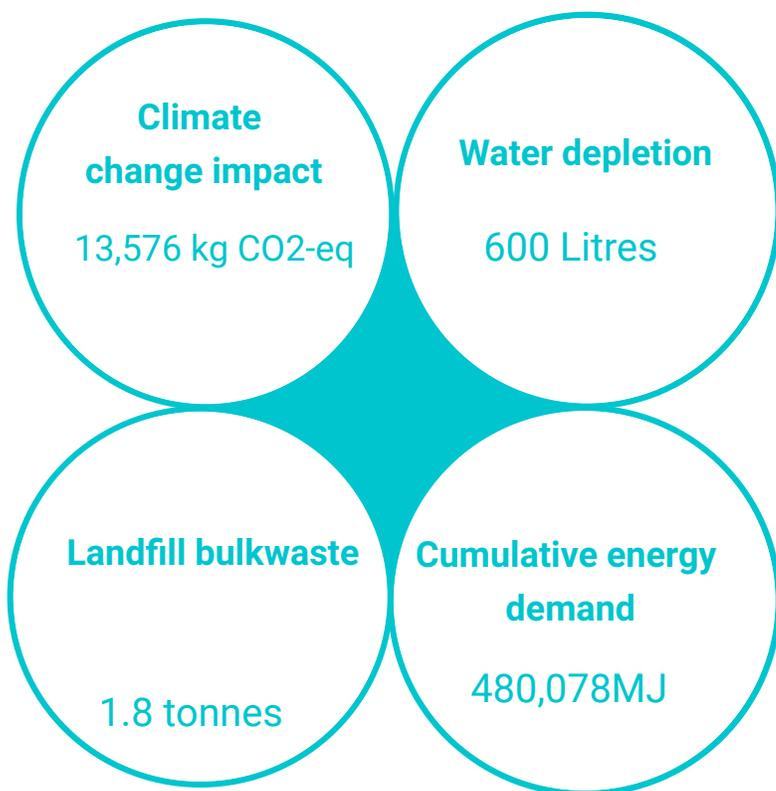
### Embodied Resources in FRI products(annual)



\*Ecoinvent is a lifecycle inventory database that contains documented process and input data for several products.

## Lifecycle impacts associated with food processing

We conducted a lifecycle impact assessment based on processes and inputs involved in making CSIR-FRI agri-food products. The current system of agri-food processing at CSIR-FRI similar to other processing facilities in the country, generates some lifecycle impacts. The lifecycle impacts are highlighted to show the environmental cost associated with CSIR-FRI current system of processing. Four impacts estimated related to greenhouse gas emissions (climate change impact) and cumulative energy demand\*, water depletion and landfill bulk waste.



## Circular economy practices in operations at CSIR-FRI

Within the processing operations at CSIR-FRI, we identified some activities that are line with a circular system of operation. Some of the crop food waste generated during processing are redirected for use in other products. For instance, the yam and cassava peel waste which are generated during the flour production are used to grow edible mushrooms which are in turn sold to the public. Some of the of the high quality cassava flour is used for ethanol production.

### Opportunity for circular economy

The operations at CSIR-FRI is not fully circularized as there is bulk waste that either ends up at the landfill or at the incinerator plant. Opportunities for circular economy therefore must be explored to see how best these wastes can be repurposed or recycled for use in other product value chain. The 1.8 tonnes of landfill bulk waste estimated represents the environmental cost associated with the linear system of production.

\*Cumulative Energy Demand (CED) of a product represents the direct and indirect energy use throughout the life cycle, including the energy consumed during the extraction, manufacturing, and disposal of the raw and auxiliary materials (Huijbregts et al, 2006)

### 3.3 Summary of Impacts and Policy Implications

Our findings concerning embodied resources in crop production highlights the need to develop strategies to reduce food losses along the agri-food value chain. According to data compiled by the Ghana Statistical Service (GSS), Fertiliser imports and consumption in 2018 alone was approximately 300,000 tonnes. This implies that for every food loss in agri-crop production, the country loses out on these embodied inputs of production. The findings on embodied resources gives an idea of the need to have an agri-food circular economy that starts right from the beginning of the food value chain and considers creating more agri-food processing avenues that can reduce food loss especially on the farm. In fact initial interview with CSIR-FRI confirmed that even their current annual production fell short of the demand for their products. In other words, there is more demand for their agri-food products than they can currently supply. This implies the need for government of Ghana to commit investment and resources to expand operations of the CSIR Food Research Institute.

Although identifying the embodied resources in crops is a critical step towards the need for circularized agri-food, it is equally important to also measure environmental impacts during the agri-food processing stage. The study also highlighted how some of the environmental lifecycle impacts (landfill bulk waste) of current operations at CSIR-FRI are reduced through circular practices; the recycling of food waste such as yam peels to produce edible mushrooms. In making the case for an agri-food circular economy, we must ensure the processes of a circularized production potentially leads to decrease in environmental impacts. Due to lack of data from CSIR-FRI, we were not able to estimate and compare the circular economy model to that of the linear system to confirm if indeed the circular economy is environmentally advantageous.

There is the opportunity to scale up operations of these circular economy business models currently at CSIR-FRI. Such a strategy fits in perfectly with the Ghana's government policy of One district, One factory (1D1F), which was launched. Food loss and waste continues to be a major problem for agri-food farmers in Ghana, and therefore it is evident that circular economy could play a major role in addressing this challenge. Of course the move to agri-food economy is not dependent on the actions of Government alone but rather calls for a multi-stakeholder approach from the actors within the value chain. In view of that, the next section of the report focuses on findings from activities during a stakeholder workshop organized and a consumer survey.



Some participants at the Stakeholder workshop organised at CSIR-Food Research Institute, Accra

## 4. SOCIAL ANALYSIS OF CIRCULARIZED AGRI-FOODS

### 4.1 Introduction

We believe transition to an agri-food circular economy, could depend largely on the society's acceptance and role in adopting circular economy practices. Beyond the environmental and economic dimension of adopting an agri-food circular economy, it is important that the social sustainability angle is also considered. To achieve this, a stakeholders workshop and an online survey on consumer awareness and perception were used to gather relevant data that sought to capture the social sustainability of agri-food circular economy and inform policy decisions. We report on some of the key findings and discuss the implications for developing a agri-food circular economy in Ghana.

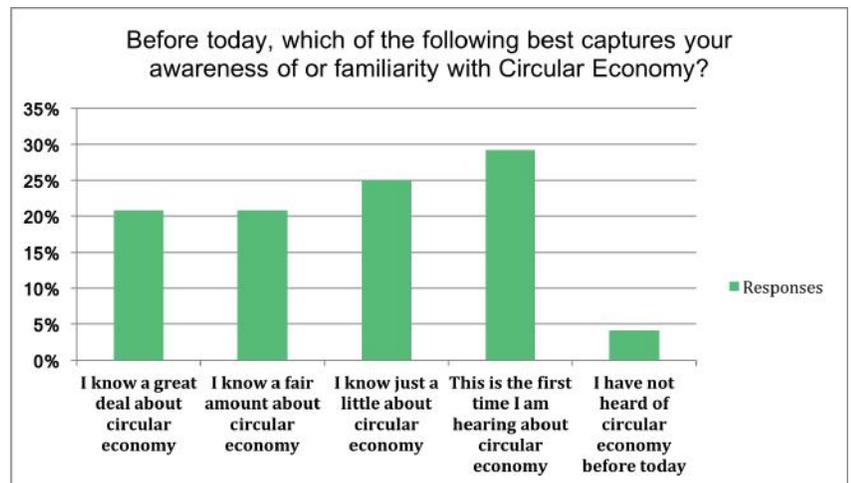
### 4.2 Stakeholders' Perceptions of Circularized Agri-Foods

A stakeholder's workshop was held in Accra at the CSIR-Food Research Institute on Tuesday, 20th October 2020. The objective of the workshop was to gather information from participants on their knowledge and awareness of circular economy and related core themes. In addition, we used focus group sessions to engage participants in discussions on the enablers and barriers of circular economy policy development in Ghana's Agri-Food sector.

Thirty-one (31) persons representing various Institutions/actors participated in the workshop. Twenty-One (21) of the participants were physically present while ten (10) participated online. Participants were drawn from Research and Academia, Government and Policy Agencies, Non-Governmental organisations, actors in the food value chain (farmers, agri-food processors, etc) and agricultural waste management businesses. The stakeholders were engaged, and interesting discussions were held on how circular economy can make its way to national policy agenda in Ghana's agri-Food sector. Policy agenda setting for circular economy in most countries including Ghana requires evidence base research that informs decision making and therefore the results of the project serves as an important source of reference in this regard.

### Stakeholder awareness or familiarity with circular economy concepts

Using a survey, stakeholders were first asked about their level of awareness on circular economy. It was encouraging to know that although 30% of participants said this was their first time of hearing about circular economy, collectively 65% said they knew a great deal or had a fair or little knowledge about circular economy.



### Potential benefits from a Circular Economy Programme

An open discussion was held where participants discussed the potential benefits that could be derived from a circular economy. A summary of some of the benefits raised by participants are highlighted below:

1. **New product development from recycled materials:** Stakeholders believed that an agri-food circular economy could lead to new product development through the recycling of waste materials.
2. **More job opportunities:** Closely linked with new product development from recycled materials, participants also thought this could translate to more job opportunities from the new business opportunities created.
3. **Cut down on importation:** Participants also believed agri-food circular economy could potentially contribute to increase in the demand for locally produced products and consequently lead to a cut down in imported goods.
4. **Add more value to products:** Participants view circular economy in agri-food value chains as an opportunity to enhance value addition.

Using the survey, stakeholders were asked about their thought on who stands to benefit the most if circular economy and its associated technologies were adopted within Ghana's agri-food value chains. Participants felt that agri-food processors stood to benefit the most followed by food waste management agencies and farmers.

## Barriers of Agri-food Circular Economy in Ghana

The Second part of the workshop was the, "Discussion Session" where participants were divided into groups to discuss the topic, "Identify the key constraints limiting the circular economy of Ghana's agri-food value chain from the stakeholder's perspective".

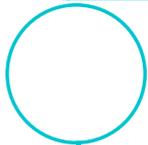
According to the stakeholders, the following are some of the factors they believe are potential barriers to limiting circular economy initiatives:

1. Inadequate information sharing about ongoing ideas on circular economy
2. Absence of legislation and enforcement
3. Lack of funding for investments
4. Low marketability of products
5. Improper market research on new products
6. Low rate in adoption of innovative technologies

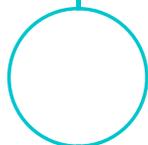
Stakeholders also identified believed the following three measures were essential in removing some of these barriers

1. Information sharing
2. Budgetary Allocation for innovation
3. Stakeholder involvement

### Quotes from participants



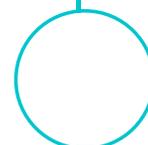
"We need to target what consumer need...we have not done well on consuming our local foods.We need to spur the uptake and marketing of our local foods and drive production and invariably reduce production cost"



"We have talked a lot about education but the act of recycling is so remote...we need to bring the concept into reality and make it closer to all"



"Need for national agenda...the National Development Planning Commission (NDPC) must take a decentralized approach based on a national agenda...element of zero waste (NDPC)"



"There is a lack of proper regulation to encourage adoption of needed changes and processes"

## Stakeholder risk perception on agri-food circular economy

Stakeholders were also asked on their perceptions on risk associated with implementing an agri-food circular economy in Ghana. They were asked to indicate to what extent they agreed or disagreed with the following statements on risk associated with implementing circular economy in agri-food value chain.

### Stakeholder risk perception

- i. Circular economy and the technologies associated with it may negatively impact the environment
- ii. Circular economy and the technologies associated with it may be too expensive for agri-food businesses and the government to adopt
- iii. Circular economy may cause some people to lose their jobs within the agri-foods value chains in Ghana
- iv. Circular economy will lower the drive of policymakers to focus on improving food security among poor households in Ghana
- v. Circular economy is more about profit-making than benefiting the public

### **Key Findings**

**i) Negative environmental impact:** 42% of stakeholders strongly disagreed that implementing circular economy would lead to negative impact on the environment. This presupposes that participants recognize and are aware of the negative environmental impact of a linear system of production and waste generation. Only 5% were of the opposing opinion that there was a risk of circular economy negatively affecting the environment..

**ii) Technologies may be too expensive:** 37% of stakeholders somewhat agreed that technologies associated with agri-food circular economy may be too expensive for agri-food business and the government to adopt.

**iii) Risk of job loss:** 37% disagreed that agri-food circular could potentially lead to job loss. However 26% were of the view that there was a risk of job loss.

**iv) Counterproductive to policy on food security:** 68% of stakeholders either disagreed or strongly disagreed with the statement that promoting an agri-food circular economy agenda could end up being counter-productive to policy driven initiatives on ensuring food security.

**v) Profit over People:** Here, we wanted to find whether stakeholders thought that there was a risk of profit making from business opportunities in an agri-food circular economy taken the lead over how it affects people. Overall we found that, 69% of stakeholders strongly disagreed or disagreed with this assertion.

### 4.3 Consumers' Perceptions and Preferences of Circularized Agri-Foods

It is expected that consumers who happen to be at the end of the agri-food value chain would play a vital role towards the transition to a circular economy. Consumer attitude and behavior can determine to some extent the scale at which agri-food circular economy is deployed. It is therefore imperative that studies capture the public perceptions and preferences to guide policy. In line with this objective, a nationally representative survey was carried out with 1000 respondents randomly sampled from the Ghanaian populace. The survey was conducted from 15th to 21st December, 2020. Questions on the survey sought to gather data on the following main areas:

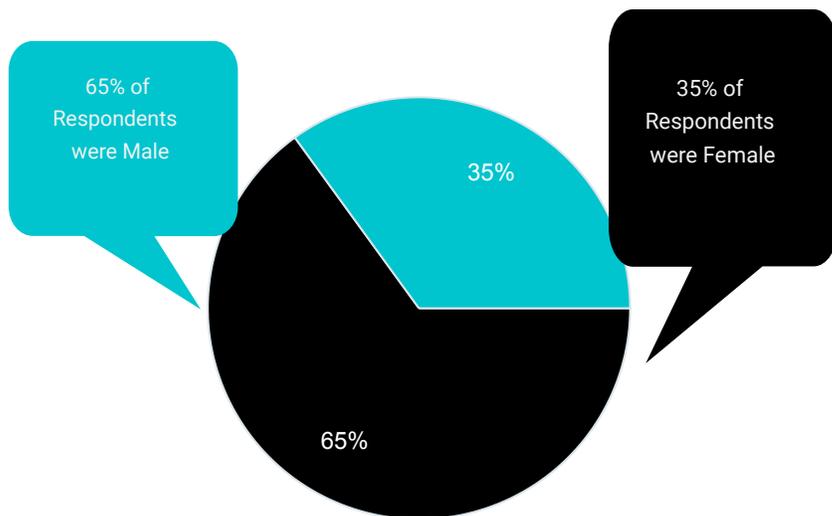
- Awareness of circular economy
- Preferences for circularized agri-foods
- Green perceptions and behaviours

Key findings from each of these areas are presented in this section.

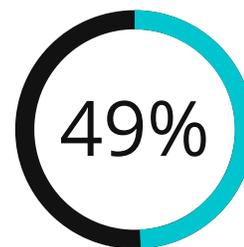
**Age:** Majority of the respondents(60%) are aged between 25-34. 20% of respondents were between the ages of 18-24 and 15% are aged between 34-44. The proportion of respondents falling between age 45 -54 and 65+ were 3% and 2% respectively.

**Education:** Majority of respondents have attained first degree university education representing 64% followed by 27% who had postgraduate degrees.

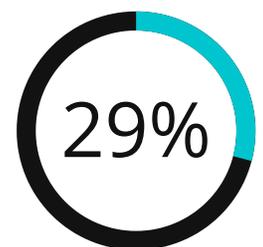
The survey respondents were taken from a nationally representative sample, with participants from all sixteen regions of Ghana. For easy presentation, the 16 regions have been categorized into 4 groups.\*\*



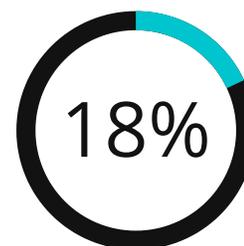
South-East Regions



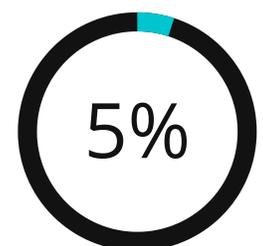
Central Regions



Northern Regions



South-West Regions



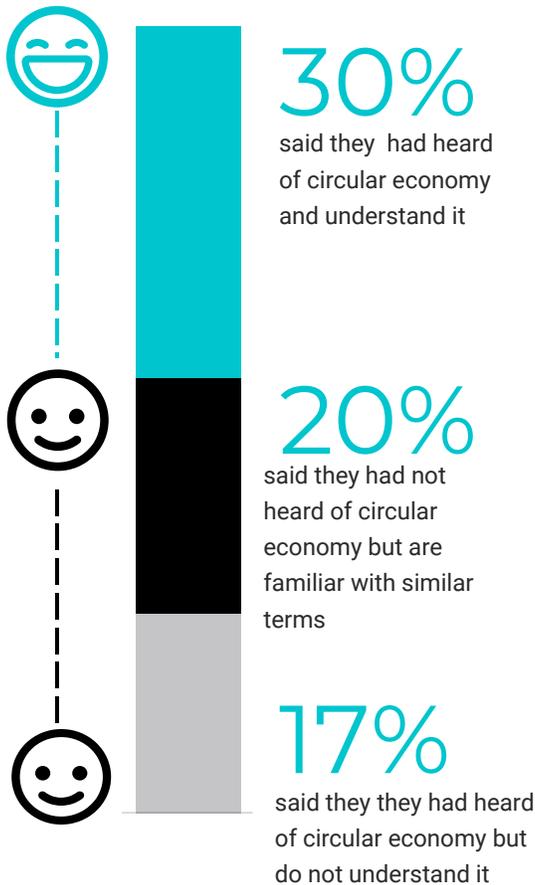
\*\* These are the breakdown of regional aggregation into four groups.

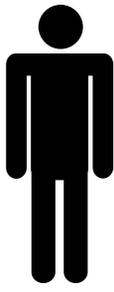
1. South East Regions: Greater Accra, Volta and Oti. 2. Central Regions: Central, Ashanti, Eastern and Bono East 3. Northern Region Regions: Savannah, North East, Upper East, Upper West and Northern 4. South-West Regions: Western, Western North, Ahafo, Bono

## Awareness of Circular economy

The level of awareness of circular economy among Ghanaian consumers was varied. We first asked whether they had heard of the term 'circular economy'. We found that for 32% of respondents, this was their first time of hearing of the term, while 17% said they had heard of circular economy but did not fully understand what the term meant. However when asked about their awareness of the six principles of circular economy (recycle, repair, re-use, reduce, rethink and refuse), we realized that from that perspective, circular economy was not entirely new to the Ghanaian consumer. Recycle, repair, reuse and reduce were the most popular principles of circular economy known to Ghanaians. The least popular circular economy principles were refuse and rethink.

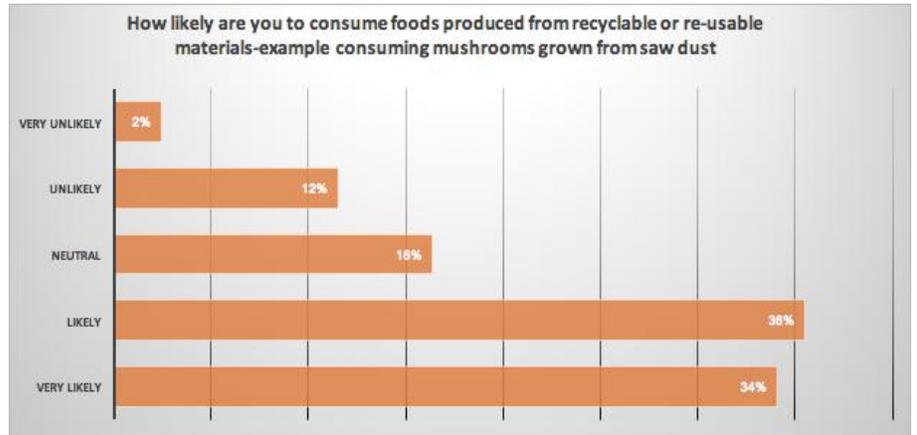
Circular Economy Concepts	% of Respondents
Recycle	21%
Repair	17%
Reuse	18%
Reduce	17%
Re-think	15%
Refuse	12%



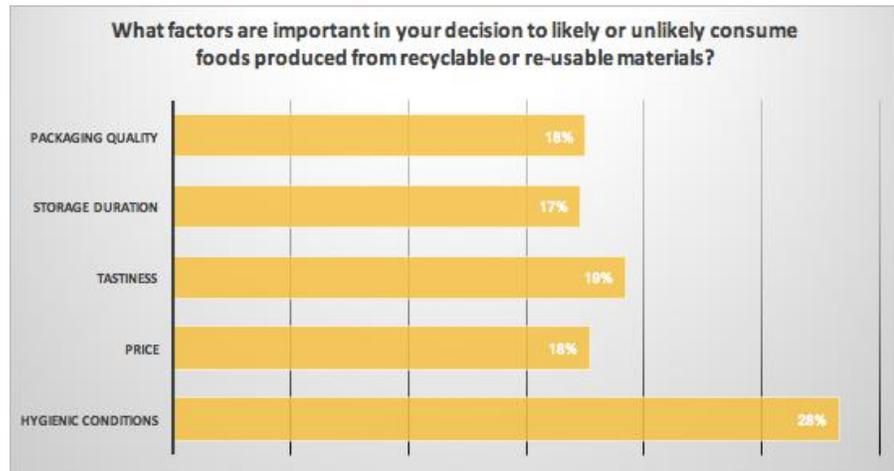
**32%**  OF PARTICIPANTS HAD HEARD OF CIRCULAR ECONOMY FOR THE FIRST TIME

## Preferences for circularized agri-foods

As stated in earlier sections of the report, the Food Research Institute undertakes some circular economy practices at their agri-food processing facility. These include the production of edible mushrooms grown from saw dust and food crop waste like yam peels. Consumers were asked on how likely they are to consume such foods knowing that they have been made from recyclable or re-used materials. Overall, 70% of Ghanaian consumers said it is very likely or likely that they would consume such products. 12% said they are unlikely to consume and 16% were neutral.

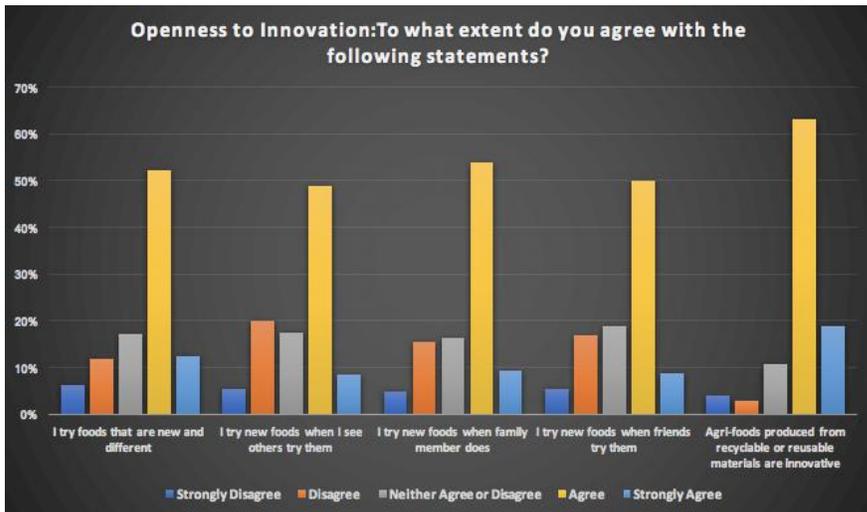
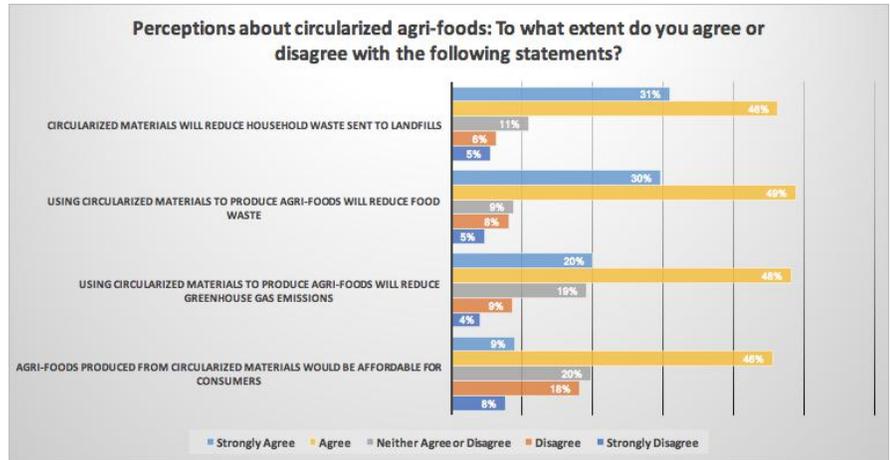


Next, we decided to probe further into the factors that influence consumers decision to consume such foods produced from recyclable or reusable materials. Among the factors, the hygienic conditions of the products had the most influence on Ghanaian consumers in their decision to consume circularized agri-food products representing 28% of respondents. The next influencing factor for consuming circularized food was tastiness. Price and packaging quality had the same levels of influence among the Ghanaian consumers. The factor with relatively low influence compared to the other factors (price, hygiene, packaging quality, tastiness) was storage quality.



## Green Perceptions and Behaviors

Consumers perception about circularized agri-foods were collected by asking about their level of agreement. Thirty-one percent (31%) of Ghanaian consumers strongly agreed that circularized materials will reduce household waste sent to landfills with only 5% strongly disagreeing. When asked whether circularized materials used to produce agri-foods would reduce food waste, 49% strongly agreed, while 20% disagreed. 48% of the consumers also agreed that a circular agri-food economy would reduce greenhouse emissions. 48% of the consumers also agreed that a circular agri-food economy would reduce greenhouse emissions.



In transitioning towards an agri-food circular, we believe that the Ghanaian consumers' openness to innovation would be a key factor. 60% of Ghanaian consumers agreed that agri-foods produced from recyclable or reusable are innovative. Overall we found that the Ghanaian consumer is opened to trying food that are new and different. The average Ghanaian consumer is mostly influenced by their Family and friends in their willingness to try new foods.

## 4.4 Summary of Impacts and Policy Implications

Final question on the survey, asked respondents about whether they thought the findings of the survey could influence national and local authorities in supporting and promoting circular economy within agri-food supply chains. An overwhelming majority(96%) believed this could be achieved.

Findings from the stakeholders workshop and consumer online survey have important implications on how the transition to agri-food circular economy can be achieved. The development and acceptance of circular economy business models relies on how the different factors raised during the study can be addressed. According to stakeholders, some of the critical key barriers to agri-food circular economy were lack of government legislation and enforcement, inadequate investment funds for innovative products and limited market research on circularized products.

For the Ghanaian economy, the agri-food processors are seen as the key stakeholder beneficiaries of an agri-food economy policy. Linking that to the results of the consumer survey, we can deduce that for such a circular agri-food business model, we need to incorporate a marketing strategy that centers on the product's hygiene, taste and price. The average Ghanaian consumer is open to innovation but is mostly influenced by similar attitudes from family and friends.

Addressing the perceived risk of circular economy is also vital. For instance, some of the key concerns identified during the survey data, was the perceived risk of job loss, as a result of introduction of technological and innovative agri-food circular economy business. The government can design policies that seek to increase awareness and educate the Ghanaian public of the benefits of circular economy.



## 5. ECONOMIC ANALYSIS OF CIRCULARIZED AGRI-FOODS

### 5.1 Introduction

Economic assessment of circular economy in general are usually conducted from the macro-level, meso-level or micro-level. For this project, we adopted a micro-level approach by focusing on a single organisation or business. Although this approach may limit the ability to generalise findings, it is still beneficial in highlighting relevant case studies of agri-food economy that can be expanded.

This section looks at CSIR-FRI's agri-food processing, identifies elements of circularity in place and the economic benefit of such. There are three main groups of agri-food crops that the Institute uses in manufacturing its product namely, root and tubers, cereals and grains and fruit and vegetables. We collected data on the average production volume, annual production and sales and profit. of these products

### 5.2 Embodied Economic Impacts of Circularized Agri-Foods

We accessed the CSIR-FRI products produced from two crop groups that is root and tubers and cereals and grains. These crops are regular staple foods in Ghana that contribute significantly towards food security. FRI sources different kinds of root and tuber crops (plantain, yam, cassava, cocoyam) from smallholder and commercial farmers and turns them into agri-food products, mainly flours. Annual production volume averages 11,000 units, bringing in annual sales of approximately GH¢138,000. The profit margin from the sale of these agri-foods is estimated at 18%.

The cereals and grains are processed into five different agri-food products. Annual production volume averages 8000 units, bringing in annual sales of approximately GH¢87,000. The final products are sold at a profit margin of 18% except for the Fermented maize meal which is sold at a profit of 5%.

The waste generated from the processing of these crops include maize husk, crop peels, waste water and rejected damaged crops. As previously stated in previous sections of the report, some of these waste is channeled into producing other products while the rest is generally not reused, but sent to the landfill or incinerated.

The relevance of CSIR-FRI's operations to circular economy is first analysed from their role in reducing post-harvest losses. Although specific data on how much they pay the suppliers (farmers) were not available, data on their production cost data gives some indications on the profit passed on to the crop farmers.

Another perspective where we see principles of circular economy in place is the fact that by processing these crops, CSIR-FRI extends the shelf life which translates into reduction in food loss. This an important factor in achieving an agri-food circular economy because it aims at preventing waste in the first place.

Figure A: CSIR-FRI Branded Agri-food products from root and tubers

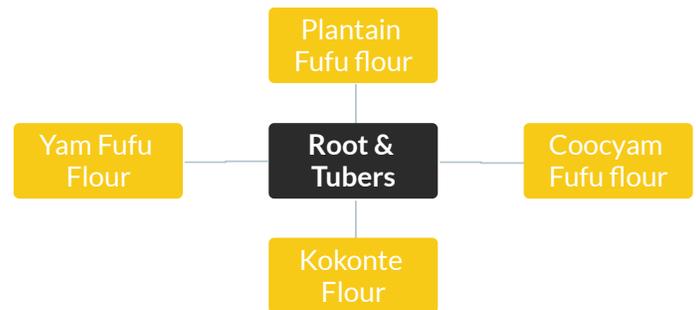
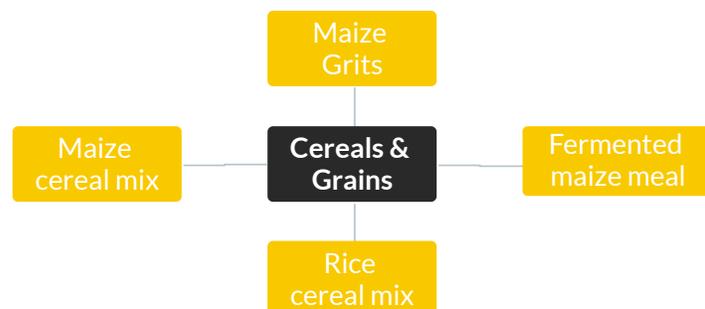


Figure B: CSIR-FRI Branded Agri-food products from Cereals



## 5.3 Summary of Impacts and Policy Implications

The economic impact of agri-food CE practice at CSIR-FRI can be summarized under the following:

**Profit to farmers:** Agri-food processing operations at CSIR-FRI relies on raw material purchases, including the agri-food crops from small holder farmers. This increases the income of farmers and stimulates extra production of agri-food crops.

**Profit to FRI:** The profit margins is an indicator of the revenue that is made from having a circular economy in place from the view point of reducing post-harvest losses. These economic gains would not be made in the absence of the new product development produced at CSIR-FRI. The new products produced from some of the food waste generated, when sold also brings in revenue for the Institution. CSIR-FRI currently does not produce enough to meet market demand. This means that there is a consumption gap that needs to be filled leading to increase in potential profits.

The economic impact of CSIR-FRI extends beyond its boundaries. As the country's leading food research institute, they engage in sharing of technical knowledge on food processing operations. The Institute regularly organizes training workshops where they transfer knowledge acquired from their processes to various individuals and organisations involved in agri-food processing. *Though the analysis conducted is at the micro-level, referring to a single firm, the impacts could be viewed also from a macro-level perspective in terms of the other agri-food processing entities in the country. Collectively, agri-food businesses generate employment for the economy and these employees also acquire new skills which enhance the human resource in the country.*

Despite the above positive economic impacts, CSIR-FRI's current operations still generate some waste that is not utilized as a resource. These end up at the incinerators or at the landfill. There are some associated costs of these waste management options, although due to incomplete data on these activities we are unable to make accurate estimates of this cost. The main reason why some of the waste ends up in unsustainable waste management activities, is mainly due to the lack of technical know-how and resources needed to convert the waste to a resource. The Government must therefore commit and make economic investment into research and development for converting these waste into a resource.

## 6.CONCLUSION: A TRIPLE BOTTOM LINE VIEW OF CIRCULARIZED AGRI-FOODS

### 6.1 Summary of Main Findings

In this section, we present a brief summary of some key findings in relation to the triple bottom line analysis (economic, environment and social) of agri-food circular economy in Ghana.

#### Environment

- **Reduction in food loss waste:** The problem of food loss and waste in developing countries including Ghana is more prevalent at the production and post-harvest stage, compared to developed countries where food waste occurs mainly during consumption stage. The Food Research Institute (FRI) plays a key role in reducing food surplus waste at the farm level. The institute through the use of scientific research are able to develop new and innovative agri-food products from several food crops. By estimating some of the embodied resources (water, fertiliser, manure, packaging) associated with food crop production, the report showed how operations at FRI if non-existent, would consequently imply these resources are wasted alongside. We believe circular economy begins from the very top of the value chain where raw material extraction occurs and therefore creating avenues that prevent waste from occurring in the first place is a positive step towards achieving an agri-food circular economy.

- **Environmental impacts of linear production model:** Through the use of lifecycle assessment method, we were able to estimate the lifecycle impacts associated with the annual production of FRI agri-food products based on a linear production model. The impacts measured including greenhouse emissions, water depletion, cumulative energy demand and landfill bulk waste enabled us to see the 'environmental cost' associated with operating linear processing model.

Although at the moment it seems that little can be done to reduce some of the impacts (greenhouse emissions and cumulative energy demand), other impacts particularly landfill bulk waste presents opportunities to develop a circular economy model where the waste is recycled or reused.

- **Agri-food circular economy practices:** The circular economy business model at CSIR-Food Research Institute is a 'near closed loop system' in that, some of the waste generated are recycled and used to produce new products, while there are still some waste generated during the production that ends up at the landfill. Waste streams such as crop peels and sawdust are recycled and used to produce edible mushrooms. Some of the waste is also used to produce biodegradable compost bags. However, some of the landfill bulk waste ends up at incinerators which has negative impacts on the environment.

"The Food Research Institute plays a vital role in reducing

food surplus waste  
at the farm level"

## **Social**

- **Stakeholder Awareness and perception:** The findings showed that there is some appreciable level of awareness of circular economy among the stakeholders (farmers, agri-food processors, distributors, government, financial institutions) in Ghana's agri-food value chain. Stakeholders believed that lack of government legislation and enforcement, inadequate investment funds for innovative products and limited market research on circularized products are among some of the barriers to agri-food circular economy in Ghana.

- **Consumer preferences and perception:** We found that Ghanaian consumers play a vital role towards achieving an agri-food circular economy. Out of the 1000 respondents that took part in our survey, it was revealed that the preferences for circularized agri-food products depended largely on consumers' perception on the three factors namely hygiene, taste and price of the product. The overall level of circular economy awareness among the consumers was however low although they were familiar with some of its principles such as recycling. In terms of openness to innovation, we found that the average Ghanaian consumer is mostly influenced by their family and friends in their willingness to try new foods.

## **Economic**

**Profit creation:** The economic impact of CSIR-FRI's operations is seen in the key role the Institution plays in terms of profit creation for actors within the value chain. First, the farmers that supply the crops, profit from selling to CSIR-FRI. Secondly, CSIR-FRI in turn also makes profit margins from processing these crops into various food products. Although the analysis is done at the micro-level analysis, it is still indicative of the the massive role that agri-food processing on the whole plays in the Ghanaian economy.

**Cost of waste management practices:** Some of the waste generated during the agri-food crop processing is converted into products of economic value. However we noticed a significant portion of waste still ends up at landfill site or incinerators which also comes at an economic cost. This associated cost of waste management practices is a reflection of the unsustainable economic cost in the absence of a truly circularized system of agri-food production.

## 6.2 Recommendations

The following recommendations are suggested as part of measures that can be taken to ensure a transition of Ghana's agri-food sector to a circular one.

### ***Set up and expand food waste valorization plants***

The next phase of Agri-Food CE research should be focused on expanding food waste valorisation opportunities identified. Waste valorisation is a process where waste is converted into useful resource. This represents real steps towards 'closing the loop' at the end of the value chain. Since CSIR-FRI has the technical resources and expertise, the Ghana government can support the institution in creating pilot case studies to demonstrate the technical feasibility of different valorisation technologies. Upon a successful pilot scheme, then efforts can be scaled up and food valorisation plants can be set up leading to the creation of new and sustainable value chains.

### ***Technological innovations***

A necessary shift towards circularity requires advances in technological innovations. Technological innovations can potentially increase efficiency in resource use. For instance some technology innovation could enhance information and data sharing among stakeholders within the agri-food value chain. Farmers knowing exactly the quantity of food to produce to meet demand could prevent some post-harvest food loss. This can be facilitated by smart agriculture such as the use of drone technology to estimate and spread the exact quantity of fertilisers and pesticides on farms.

### ***Increase awareness and public participation in waste separation at the household level***

Consumer behaviour plays a vital role towards achieving food waste valorisation. For developed countries some fundamentals of agri-food CE approaches already exist and are actively practiced such as separation of food waste from other general waste. The situation is however different for the typical Ghanaian household where food waste is added together with other general waste.. The unseparated waste are picked up by waste management companies such as Zoomlion Ghana Ltd and majority ends up at their landfill site or incinerators. To avoid this and increase the chance of food waste valorisation, we recommend that more public awareness and education is carried out to increase participation in food waste management practices at the household level.

### ***Government regulations and incentives***

From the stakeholder workshop and consumer survey, we see that the principles of circular economy is not entirely new to the Ghanaian populace. However, the current practices of waste separation at both the commercial and household level is not widely practiced because there is no specific regulation to enforce such behaviors. Regulation can drive the move towards circular economy once government makes certain practices a requirement. Sometimes regulations on its own can be counter-productive if some incentives are not put alongside the regulations. For instance, if consumers are to receive some economic benefit/compensation from household waste separation, then perhaps they can be motivated to participate.

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