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Food Wastage in Cassava Sector of Ghana

- Winners and Losers

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Abstract

Reducing food wastage has been identified as a sustainable and necessary solution for food insecurity, poverty and hunger alleviation in this fast-growing world, especially in Sub-Saharan Africa (SSA). However, food wastage abatement has sectorial trade-offs (winners and losers) and variations which need to be explored empirically to determine if this solution is worthwhile. Furthermore, despite the relevance of staples in SSA economies and their significant share in food loss, there are relatively few literature that analyses the economic impact of its reduction. Thus this study assesses and compares the economic impact of a cassava prevention policy, integrated wastage management policy and a combined policy on food security, rural-urban income distribution, economic growth, output expansion, net waste generation, trade-off between cooking and work income, food wastage footprint as well as employment in a cassava export driven Ghanaian economy using a mixed methods approach; namely food wastage fixed price multiplier model, value chain analysis and documentary analysis.

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Abbreviations

SAM	Social Accounting Matrix
CSIR	Council for Scientific and Industrial Research
DADTCO	Dutch Agricultural Development & Trading Company
DFID	Department For International Development
ECOWAS	Economic Community Of West African States
FAO	Food and Agriculture Organization
FCR	Fresh Cassava Root
GDP	Gross Domestic Product
HQCF	High-quality Cassava Flour
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
MDG	Millenium Development Goals
MOFA	Ministry of Food and Agriculture
RTIMP	Root and Tuber Improvement and Marketing Programme
SDG	Sustainable Development goals
SSA	Sub-Saharan Africa
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development

Glossary: Key terms

Poor	People currently earning less than $2 per day, equivalent, at purchasing power parity
Vulnerable	People at risk of falling into poverty in the near future
Food security	Physical and economic access to food that meets people's dietary needs. This document uses food inadequacy, a daily calorie intake below FAO recommen ded levels, as the primary indicator of food security.
Food loss	The decrease in edible food mass at production, post-harvest, processing, and distribution in value chains directed to human consumption
Food waste	Food fit for human consumption being discarded at the retail or consumer level
Food wastage	The combination of “food loss” and “food waste
Agricultural Production loss	Spilled or damaged agricultural output during harvest, sorting, and handling
Postharvest handling and storage loss	Losses due to spillage and degradation during handling, storage, and transportation off the farm
Processing loss	Losses due to spillage and degradation during industrial or domestic processing, including crops sorted out or lost during process interruptions
Distribution loss	Losses experienced while in the market system, e.g., in wholesale markets, supermarkets, retailers, and wet markets
Consumption waste	Waste incurred at the household level
Degradation/ Deterioration	Decrease in volume, edibility, and nutritional value over time, as foods lose th eir original color, flavour, odour, and consistency
Discards	Food intentionally thrown out by any actor along the value chain.
Spoilage	The decay of food due to yeasts, moulds, or bacteria, which makes it unsuitable for consumption.
Durables	Cereals (excluding beer), which include: wheat, rice (milled), barley, maize, rye, oats, millet, sorghum, and other cereals
Perishables	Roots and tubers (i.e., potatoes, sweet potatoes, cassava, yams, other roots) and fruits and vegetables
Reuse	This refers to the collection of food still fit for consumption but close to expiry ,thus cannot be sold at retail markets, or left-overs at the end of a banquet or events by food banks transformed into food parcels and meals and then supply them to second charities/NGOs/ religious organizations to those who are in food poverty or food insecure
Recycle(compost and animal feed)	Composting is the process of turning organic household waste into fertilizer through aerobic fermentation’. Equally, Animal feeding refers to the feeding of food waste to animals such as pigs, dogs, worms, chickens, etc.
Disposal	Food wastage is disposed via landfills (engineered, traditional), incinerators or sewers. For the purpose of this study, this excludes traditional landfills and sewer disposal. Incineration is a method of disposing of food wastage via combustion to reduce the waste to ashes.
Illegal dumping	We define this as the informal disposal of food wastage or formal disposal of wastage into traditional landfills for the purpose of this study
Energy recovery	This refers to the conversion of food wastage into biogas for the creation of renewable energy via anaerobic digestion
Economic impact	Increases in the incomes and output of supply chain agents (for price and quantity effects of food wastage see appendix)

Avoidable food wastage	Avoidable food wastage refer to food thrown away because it has perished or exceeded the date of expiry that were, prior to disposal, edible, but at the time of disposal deteriorated to become inedible. e.g. Broken and /or deteriorated cassava roots
Unavoidable food wastage	This refer to food that is not edible under any normal circumstances. e.g. Including apple cores, banana skin, bones, cassava skins etc. Additionally, production, storage, transportation, and processing losses that are not avoidable with best available technologies and reasonable extra costs are also classified as unavoidable.
Possible avoidable	This refer to food and drink that is considered edible by some and not by others (e.g. apple peels), or that can be eaten when prepared (e.g. potato or pumpkin skins). Possibly avoidable food waste can also be disposed of due to cosmetic issues or specific quality criteria (e.g. small cassava roots, cassava leaves).

Chapter 1: Introduction

1.1 Background

The insecurity of feeding sustainably a world population which is expected to be more than 9 billion people by 2050 coupled with climate change, increased demand for food as a result of the increased population and increased use of food crops as biofuel or fodder, increase in scarcity of natural resources such as land, water and plant species and volatile food prices have brought back global debates on minimizing food wastage (Parfitt, Barthel, & MacNaughton, 2010); (Kwasek M. , 2012)). Meanwhile, the Food and Agriculture Organization of the United Nations (FAO) estimates that about 32 percent of global food production is lost or wasted annually with Sub-Saharan Africa(SSA) having the highest annual food wastage at 37% as well as uneven improvement in access to food, income growth and poverty reduction (2011). This is equivalent to 545 kilocalories per person, 23% loss of food calories, across SSA (lipinski, et al., Installment 2 of Creating a sustainable food future, 2013). Also according to FAO's study, food loss constitute a larger component of SSA's food wastage with the highest contributing sector being roots and tubers, predominantly cassava (*manihot esculenta*), because of their perishable nature.

However in SSA, about 25% of its population do not have physical and/or economic access to enough food to sustain a healthy life whereas food loss contribute to at least 15% decrease of saleable volumes of food for the 470 million smallholder farmers and negatively affects the 290 million agriculture downstream industry workers and their families (The Rockefeller Foundation, 2013). In addition, food wastage represents wasted pressure on the already scarce natural resources which are used in food production which directly worsens as the world increases food production without reducing food wastage to fill its feeding gap (Searchinger, et al., 2013); Cuellar and Webber (2010)).

In addition, food wastage is estimated to emit about 3.3 billion tons of greenhouse gases into the earth's atmosphere (FAO, 2014) worth 21 and 293 times greater global warming potential respectively than carbon dioxide (Hertwich, 2011). More so, since food wastage constitutes about 50-70 percent of solid waste in agro-based economies, sustainable mitigation of food wastage could significantly reduce the pressure on public waste management services and infrastructure as a result of rapid urbanization in these countries. FAO (2011) emphasized that resource efficiency and waste reduction have the potential to yield cost savings, identify new business fields, increase employment and competitiveness thereby bringing the cost of food down and increasing economic access to food.

1.2 Problem statement

1.2.1 Policymakers challenges

As a resort, Lipinski et al (2013) propose that if the EU's target of halving food wastage is extended globally. This great balancing act is expected to sustainably alleviate food insecurity by fill the feeding gap while contributing to inclusive and environmentally sustainable economic growth (Searchinger, et al., 2013). Thus, the Millennium Development Goal (MDG) target of halving the proportion of undernourished people by 2015 has been extended in the Sustainable Development Goals (SDG) number 2[1], 6[2], 8[3] and 12[4] to help achieve the World Food Summit target[5] to ensure zero hunger. Meanwhile, other studies suggest that food wastage is reduced by an increase of supply-chain agents' access to international markets and thus propose that an export-led only policy in the agriculture sector of African countries will alleviate food wastage((Durkin, 2015). On the other hand, some scholars propose an integrated waste management approach whereas some suggest a combination of policies (Papargyropoulou, Lozano, Steinberger,, & Wright, 2014). Consequently, policymakers seek to determine whether food wastage reduction will be worthwhile on the national, regional and global level, whether it is the best alternative treatment for food wastage and if yes, who it will potentially affect?

1.2.2 Researchers' challenges: Empirical and Conceptual

The food wastage discourse over the years has encompassed quantification, impact as well as effectiveness of food wastage and food wastage reduction interventions (Ratinger, 2013). However, studies attempting to address these debates have indicated that analysis of the food wastage problem is ridden with conceptual and empirical challenges. Conceptual challenges and empirical challenges refer to issues in economic analyses and data assessment of food wastage respectively (Ricker-Gilbert, Jayne, & Shively, 2013). Empirically, subsequent studies have identified that quantification methods, approaches and measurement units of food wastage vary in their cost-effectiveness, representativeness and consistency with agronomic studies and nutrition studies((Naziri, et al., 2014); (Parfitt, Barthel, & Macnaughton, 2010); (Kaminski & Christiaensen, 2014)).

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[1] End hunger , achieve food security and improved nutrition and promote sustainable agriculture

[2] Ensure availability and sustainable management of water for all at all ages

[3] Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all

[4] Ensure sustainable consumption and production patterns

[5] Halve that the number of people that are undernourished

Conceptually, although economic impact analysis of food wastage is not novel, there have been relatively few studies on the economic impact of food wastage of starchy staples on significant countries in SSA although it is second top contributor of calories in West (Affogon, Mutungi, Sanginga, & Borgemeister, 2015). Another issue has been that previous studies that assess the economic impact of food wastage reduction either do not consider that food wastage reduction is not cost-free or estimate the costs as one-to-one ignoring the heterogeneous subjective nature of food wastage, the true economic value of food wastage and the full food life cycle ((Britz, Dudu, & Ferrari, 2014; Naziri, et al., 2014; FAO, 2014; Reynolds, 2013.). Also, some studies (Reynolds 2013; (Britz, Dudu, & Ferrari, 2014); (Naziri, et al., 2014)) hold the view that although food wastage reduction is a function of technology, this technology is synonymous with food production technology. Thus, researchers seek how to model the economic impact of food wastage reduction while addressing these empirical and conceptual challenges.

1.2.3 The Cassava Problem

The African continent supplies over 60% of the world cassava market but because of the product's 65%-70% water content and 2-days shelf life, the crop inherently accrues significant food wastage, estimated to be between 40-50% losses (Naziri, et al., 2014). Also in West Africa, maintaining Cassava's food security is imperative for inclusive economic growth in the region since cassava is the second most important source of calories in the region with a small-holder-farmer-dominated production sector and a female-dominated processing sector[6]. Also, cassava production is eco-efficient in the sense that is highly adaptive to drought and poor soil condition as well as requires limited technical inputs for production. (CGIAR, 2015). Furthermore, Cassava in Ghana is increasingly being considered as a potential commercial crop than as a food security crop (Naziri, et al., 2014). Thus, the estimation that there exist significant wastage of roots and tubers in SSA and that Ghana incurs the highest physical and economic loss due to cassava wastage amongst 4 of the top 6 cassava producing countries warrants the concern of stakeholders (Naziri, et al., 2014) (FAO, 2013).

1.3 Purpose of Study

However, to the best of my knowledge, there has been no study that economically analyses the sectorial impact of cassava wastage reduction in the Ghanaian economy while considering the value chain and full-life cycle of cassava as well as the economic wastage treatment costs simultaneously. Therefore this study attempts to fill this knowledge gap. Hence, the study seeks to answer the research questions:

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[6] The gender distribution varies per country (reference)

- Who are the winners and losers of cassava wastage treatment policies in Ghana?
- What is the best policy option to deal with cassava wastage in Ghana?

Information regarding these questions will expand policy makers and cassava stakeholders' knowledge on the sectorial linkages of cassava wastage and its reduction in the Ghanaian economy. Thus, the main objective of this research is to help identify the appropriate target sectors/ institutions for food wastage treatment policies in the Ghanaian cassava sector and determine if food wastage reduction is the best policy alternative available given different policy objectives. Hence, the specific objectives of the study encompasses the following:

- Identify the cassava wastage situation in Ghana.
- Identify the winners and losers of the cassava export policy with and without the introduction cassava wastage treatment policies in the Ghanaian economy by comparing the impact of the policies on rural-urban household income distribution and the trade-off between cooking and work income
- Compare the economic impact of cassava export policy with and without the introduction of cassava prevention policy, integrated wastage management policy or a combined policy on food security, inclusive economic growth, output expansion, net waste generation , food wastage footprint as well as employment in Ghana

The objectives of this study are based on the hypothesis that cassava wastage reduction has winners and losers that vary when its sectoral linkages and the costs of wastage reduction are considered. Hence, addressing the food wastage problem in the cassava supply chain in Ghana is not a single cost-free bullet.

1.4 SCOPE of Study

Food wastage is a very wide topic to discuss in a single thesis. Thus for this study, the focus will be on the quantity effects of cassava wastage reduction in Ghana due to its aforementioned relevance in Ghana and West Africa(see appendix A part 1 for the distinction between price effects and quantity effects of food wastage). Since the quantum physical losses of processed cassava products and industrial cassava value chain are not very significant, only physical losses associated with fresh cassava roots allocated to the gari, fresh cassava roots and agbelima value chains is considered in this study (Naziri, et al., 2014). The food wastage policies considered includes the cassava export policy (which determines the baseline case for policy shocks), the cassava wastage prevention policy, the integrated cassava wastage management policy and the combined policy.

The target variables for the policies are food security, rural-urban household income distribution, economic growth, output expansion, net waste generation, trade-off between cooking and work income, food wastage footprint and employment. Food security is defined as the change in total supply from the agric-food sector as a proxy for food availability. This is because food availability from domestic production is the main source of food, income and employment in rural areas (FAO, IFAD AND WFP, 2014) . Economic growth is defined as the change in gross domestic product at factor cost (GDP). Output expansion refers to the change in agriculture sector production. Food wastage footprint is defined as the change in food wastage generated which is the change in food wastage collected since the study assumes that all food wastage generated is collected by the food wastage collection sector. Net waste generation refers to the sum of the change in waste treatment sector output; a positive change indicate that new products produced by the waste treatment method offset net waste generated whereas a negative change indicates the vice versa.

The exchange rates in 2015 were used in this study. GHS is the Ghana cedi currency for Ghana. EUR is the euro currency for most parts of Europe and USD is the United States Dollars.

Table 1 Exchange Rates

GHS	EUR	USD
1	0.22	0.24
4.55	1	4.11

1.5 ADOPTED METHOLOGY

To assess the economic impact of the cassava wastage treatment policies on the aforementioned policy target variables we extended the 2005 Social accounting matrix (SAM) and the fixed price Leontief's multiplier model to create the Full food Life SAM and the Fixed price food wastage multiplier model. To modify the SAM, we first expanded the labour account to include the cooking labour account, added cooked food to the commodity accounts and disaggregated the household institution account in a cooked food producing sector and a final demand institution. Next, we calculated the cassava wastage shares and introduced cassava wastage types accounts, FCR, AGB and GAR, to depict cassava wastage generated in the value chains along the cassava supply chain at the producer price value. We also introduced a food wastage collection account which collected all the cassava wastage generated by the cassava supply chain agents along the value chain at a waste collection fee. Lastly, we introduced 5 food wastage treatment accounts, reuse, and recycle, recovery, e-disposal and illegal dumping. The food wastage at this level were valued at the net benefit of the treatment method as proxy for the value of food wastage at the wastage treatment level.

To formulate the fixed price food wastage multiplier model, we introduced the waste treatment allocation matrix which varied the food wastage allocated to the various treatment methods and a waste prevention vector which determined the initial amount of cassava wastage generated by the supply chain agents along the cassava value chain. These two matrices were introduced as a factor of the wastage types, wastage collection and wastage treatment accounts. Due to time and resource constraint, the study relies on documentary analysis to determine the quantum and economic value of cassava wastage in Ghana which are expatiated in chapter 4 of this thesis. Furthermore, food wastage is assumed to be reduced or treated via an exogenous change in technology or economic agent behaviour in the wastage stage or wastage treatment stages of the cassava sector by changing the elements of the two matrices. Price effects, Ecosystem impact, environmental impact and social impact analyses are left for further research.

1.6 REPORT Structure

Chapter 1 gives an introduction to the thesis including the scope, justification and a summary of the methodology used for the thesis. Chapter 2 provides a literature review on conceptual and empirical issues in defining, quantifying and economically analysing food wastage. Chapter 3 explains how data was sourced for the study, the methods used for economic analysis, analysis procedure and a background of the study area. In chapter 4, results are discussed in two main parts; the documentary analysis describes the state of food wastage and food wastage management in Ghana, the cassava sector and cassava wastage in Ghana whereas the economic analysis employs the policy shocks to the baseline described in the documentary analysis. In chapter 5 a brief conclusion, recommendations and limitations of the study follows.

Chapter 2: Literature Review

In this chapter the background of the study area, the conceptual challenges of defining food wastage, empirical challenges in quantifying food wastage and the conceptual challenges in analysing food wastage economically are elaborated in four main sections.

2.1 Background OF STUDY AREA

Ghana is a West African coastal country bordered on the east by Togo, on the west by Cote D'Ivoire and on the north by Burkina Faso with a total land area of about 239,460 sq. km. Lying just above the equator, Ghana has a tropic climate with a rainfall amount that generally declines towards the north of the country. It is made up of ten administrative regions and has vegetation which varies per the county's geographical area (figure 16 in appendix B part 1). Ghana's human capital of about 24 million, which is predominantly youthful, are unevenly distributed spatially over the regions due to economic, historical, environmental and political factors due to colonial influences that spurred up urbanization along Ghana's coast for the purpose of trade, the development of infrastructure and the creation of administrative centres(Baabereyir, 2009). Meanwhile, cash crop farming, mining and trade enhanced the urbanization in the forest areas such as Kumasi, Koforidua, Sunyani, Ho and Obuasi (Baabereyir, 2009).

Ghana mainly exports cocoa, timber, oil palm, coffee, cotton and shea nuts usually in their raw state, while a wide variety of food crops are also produced by the country's farmers including cereals, cassava, yams, cowpea, peanuts, plantains, bananas and vegetables, etc. However, these latter crops are of high perishable nature and generates large quantities of organic solid waste especially in the cities (Baabereyir, 2009). However, these foods are increasingly being processed by local industries for both local and foreign markets (Durkin, 2015). In 2012, agriculture growth in Ghana as at 2012 was 2.6% worth 6,674 million Ghana cedis of which crops other than cocoa contributed 5121 million Ghana cedis (MOFA, 2015). In 2013, Agriculture contributed 21.9% of the national GDP and about 42% of employment in 2010 in Ghana (The World Bank). Although, Ghana is predominantly agro-based the contribution of agriculture to GDP in recent times has dwindled so that the recent growth rate has been significantly driven by the services sector. That is, in 2005, Agriculture contributed 42% of GDP but this have significantly fallen to 22% partly because of the high food wastage experienced by the country (GSS, 2014).

The country's average annual growth rate of GDP per capita in constant 2006 prices was 7.8 percent for the period 2005-2012 which has led to the attainment of Ghana's low middle income status (GSS, 2014). However, the country has experience poverty reduction from 52% in 1992 to 29% in 2010.

Yet these development gains has been uneven between the north and the south with the former significantly lagging behind (World Bank, 2011). For instance, although on the national level, about 5% of the people in Ghana are undernourished, in North Ghana 69% of the populace do not have adequate access to food. Meanwhile, 88% of households' livelihoods in North Ghana rely on crop production and are the most vulnerable to climate change (FAO, IFAD AND WFP, 2014) ;(see appendix B part 1).

In addition, according to the Ghana Statistical Service about 29.5 % of children in Ghana have moderate to severe stunting, 16% are underweight and 7.6% have moderate to severe wasting (Ghana Statistical Service, 2011). More than 2.2 million Ghanaians cannot afford to feed themselves with 2,900 calories per adult equivalent of food per day, even if they were to spend all their expenditures on food with as many as over 1.8 million persons living in extreme poverty in rural areas (GSS, 2012). Figures 2 and 3 in appendix B part 1, indicate the spatial disparity in the food insecurity situation in Ghana and the vegetation distribution of the country in the map of Ghana. Thus, Ghana is ranked as low-middle income and food deficit country. This is because despite some of its economic successes the country is highly food import dependent and relies heavily on external financial and technical assistance.

Nonetheless, it is estimated that 32 million youth in Africa will enter the labor force per annum reaching an economically active population of 1.6 billion people by 2050, about a third of the global rapid urbanization will be experienced in Africa by 2050 coupled with a three-fold increase in GDP per capita in SSA from 2010 to 2050(Rockefeller Foundation, 2013). Thus it is expected that the region will experience a steady shift of consumption towards higher quality and more diverse foods expanding SSA's retail sector, demand for value chain development and global food companies sourcing from smallholder farmers in developing countries. Nonetheless, agricultural research departments across Africa and Asia that study food loss by crop type (e.g., International Rice Research Institute, Stellenbosch University) indicate that postharvest loss research only attracts about 5% of all funding for agricultural research globally. Thus this study explores the potential of the Ghanaian cassava sector to tap into these positive projections via an export policy while maintaining environmental sustainability via cassava wastage reduction and management.

2.2. Conceptual Challenges in Defining Food Wastage

In defining food wastage, we consider the distinction between food wastage and waste as well as include the perspectives of agronomy, nutrition and sociology in the definition. Lastly we consider the practicality of the definition. Based on these we give a final definition of food wastage for our analysis.

2.2.1 Waste versus Food wastage

(Baabereyir, 2009) describes waste as "…unwanted or unusable materials … that emanate from numerous sources from industry and agriculture as well as businesses and households … which may be considered a source of value by others". This is based on the concept of 'resource' which states that a material becomes a resource when it gains use-value and becomes waste when it loses its use-value so that waste is "a reflection of human appraisal" (Baabereyir, 2009). Historically, public waste management was a mere pollution control exercise of removing 'bads' from human settlements (Reynolds, 2013). However, in recent years, the acknowledgement of land as a fixed resource in food production and waste management, the dangerous emissions from landfills, food insecurity as well as the substantial economic costs associated with food wastage has led to its various re-appraisals to be an economic good that can be more efficiently allocated through recycling, re-use, prevention or in energy recovery if source separated (Papargyropoulou, Lozano, Steinberger,, & Wright, 2014). As a result, FAO(1981) defined food wastage as a wholesome edible material intended for human consumption that is discarded, lost, degraded or consumed by pests at any point of the food supply chain.

2.2.2 Including Nutrition perspectives

Smil (2004) added that since agronomists suggest that food supply of 130 percent over nutritional needs guarantees food security, any supply of food beyond this quota is over-nutrition[7]. This addition to the food wastage definition allowed for the distinction between food surplus and food waste[8]. So, Food produced minus desired food surplus minus undesired food surplus that is consumed equals food waste (Papargyropoulou, Lozano, Steinberger,, & Wright, 2014). However, the current gap between the average daily nutritional needs per person and actual food available per person in high income countries is alarming and not safe guarding since according to FAO's food balance sheet retail in high income countries now make available over 3000 kcal per person per day instead of the daily requirement of 2600kcal per person (Papargyropoulou, Lozano, Steinberger,, & Wright, 2014). Also, within each of the country groups there is increasing inequalities in the access to global food and food poverty which indicates food allocation inefficiencies in these economies (Papargyropoulou, Lozano, Steinberger,, & Wright, 2014). Therefore distinguishing between food

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[7] the gap between energy value of consumed food per capita and the energy value of consumed food per capita and the energy value of food needed per capita

[8] food waste is amount of food waste that never gets eaten by humans whereas food surplus acts as a safeguard against food insecurity

surplus and food wastage enable proper food allocation for optimal food use efficiency and food security (see figure 9).

2.2.3 Including social perspectives

In reality, since the definition of edible food and waste culture varies across countries and food value, there no commonly agreed definition of food wastage (OECD, 2014; (Reynolds, 2013). So, in countries where food wastage is not sorted, it is identified as a fraction of municipal and industrial waste (Reynolds, 2013). However, this definition oversimplifies and possibly underestimates the creation of food wastage to the disposal stage of the food life cycle (Reynolds, 2013). Thus FAO (2011) defines food wastage to be a combination of food loss and food waste such that Food loss refers to decrease in edible food mass (quantitative) or nutritional value (qualitative) at production, postharvest, processing and distribution in value chains directed for human consumption whereas food waste refers to food fit for human consumption but being discarded at the retail/consumer level (see figure 8). So, food waste is related more too behavioural issues and food loss is related more to systems requiring investment and infrastructure (Parfitt, Barthel, & Macnaughton, 2010). Based on this, it is more ideal to attempt to model food waste treatments as behavioural or technological changes among economic agents than an exogenous change in final demand (Reynolds, 2013).

2.2.4 Making the definition practical

To provide a wider scope for food waste management opportunities, Stuart (2009) include edible material intentionally fed to animals or by-product of for processing diverted away from the human food chain and classified food wastage as avoidable[9], possibly avoidable[10] and unavoidable waste[11]. This classification depends on society's culture such as shared value and common practices, religious beliefs, social norms and personal preferences. Food wastage can also be classified into economic

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[9] Avoidable food wastage refers to food that at some point prior to disposal was edible or that can be eaten if food is prepared in another way. Avoidable food waste consists of food that is thrown away but is edible prior to disposal .e.g. broken or deteriorated fresh cassava roots.

[10] Possibly avoidable food wastage comprise of food that are considered edible by some and inedible by others. E.g. Cassava leaves is considered edible in parts of West Africa and inedible in the other parts.

[11] Unavoidable food waste refers to food thrown away that in natural circumstances are not edible. E.g. cassava skins, egg-shells, etc. Also, when food lost in the pre-retail/consumption stages are unable to be prevented with best cost-efficient technology available, they are considered as unavoidable food wastage.

losses and physical losses[12] (Parfitt, Barthel, & Macnaughton, 2010). In addition, to the food supply chain, value chain analysis of food wastage generation (VCA) allows for more accurate quantification of food wastage (Kleih, Phillips, Wordey, & Gregory, 2013). Parpargyropoulou et al (2014) adds that the time dimension should be considered when analysing the food waste challenge. This aspect of time refers to the material nature of food; which is it decomposes with time. This allows for the discussion of foods' transition to waste and is also known as considering the full food life cycle (FAO, 2014); (Haq, 2012). According to them, this time dimension necessitates an integrated approach such as the sustainable production and consumption approach (SCP). These additions to the food wastage definition considers the heterogeneous nature of food wastage which helps present a more accurate picture of food wastage in accounting frameworks and economic analyses (Naziri, et al., 2014)**.**

Based on these , our study defines food wastage as the edible food mass or nutrition value of food intended for human consumption less eaten food surplus that is discarded, lost, degraded , consumed by pests, fed to animals or used as by-product for processing away from human consumption at any point of the food supply chain along the food's value chains which is avoidable, possibly avoidable or unavoidable So that, food waste occurs at the retail/consumption stage due to consumption inefficiency fuelled by consumer behaviour whereas food loss occurs at the pre-retail/pre-consumption stage due to inefficient infrastructure, production-transport-processing methods and investment necessary for ensuring food longevity (see appendix A part 2).

For the purpose of this study cassava wastage, hereon referred to as food wastage, is the loss/waste of avoidable physical fresh cassava roots across the cassava supply chain and along the cassava value chain. That is, fresh cassava roots that were intentionally or unintentionally lost or thrown away in the production stage, trade and transport stage, processing stage and consumption stages of the cassava value chain which could have otherwise been eaten. Physical losses refer to food that are forgotten on the farm and spoiled /deteriorated foods that are not marketable such as broken roots (Naziri, et al., 2014). Hence, in this context food wastage only include lost or wasted cassava roots and does not include lost or wasted processed cassava products, cassava leaves or cassava skins. Food wastage or food losses hereon refers to this definition.

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[12] Economic losses are spoiled or damaged foods whose market prices have been discounted. E.g. damaged food which have been processed into de-valued products whereas physical losses refer to the volume or quantum of food lost or wasted.

2.3 Empirical Challenges in Quantifying Food Wastage

In quantifying food wastage, we compare the quantification approaches and methods currently in use and determine the method and approach that fits the definition concluded in section 2.1. We also explain how the consistency of the estimate with the perspectives of agronomy, nutrition and sociology is ascertained.

2.3.1 Quantification Methods

In most countries, developed or developing, food wastage and its policies is either mixed up with all solid waste or mixed up in organic waste (Reynolds, 2013). Hence, the actual quantum of food wasted/lost in the society is unknown due to the inability of waste disposers/disposal systems to provide detailed account of the solid waste composition, source of waste generation and waste treatment allocation shares (Reynolds, 2013). Furthermore, the quantum of waste is influenced by many factors including economic growth, demographic characteristics of the disposer as well as socio-political variables so that many waste generation studies are considered to be accurate if they have ''+/- 30% accuracy of estimates'' (Reynolds, 2013). Also, although, informal food waste disposal has an impact upon the levels of food waste formally disposed of, that waste is not captured within official waste statistics (Reynolds, 2013). Hence, to estimate the quantity of food wastage, experts have resorted to 'waste audits of bins or vehicles carrying waste or elicit stated losses form supply chain agents' (Reynolds, 2013).

The waste-bin audit method is normally done on a small-scale because it is relatively expensive and time-consuming and it is critiqued for its potential lack of representativeness and sample-bias when extrapolated to the macro-level (Reynolds, 2013). Also, the time-cost disadvantage of this approach, leads to the use of obsolete data, measurement errors and framing bias (Naziri, et al., 2014). Alternatively, the self-reported estimates method is proposed because it is relatively cheap and as a result allows for macro-scale and seasonal data collection. It is also admired for its ease in collecting comprehensive data such as value-chain data which is very relevant for policy analysis (Naziri, et al., 2014). However, it is criticized for its susceptibility to respondent bias since respondents are likely to report only the food wastage that they deem important or interpret as waste or be unable or unwilling to accurately recall what their wastage behaviour was (Reynolds, 2013); Hoj (2012).

However, the critique on respondent bias is somewhat confounded by the social perspective of food wastage that food wastage is a subjective practice since the individuals that form society have varied demographic characteristics that define their waste culture(Reynolds, 2013). Based on the fundamental economic assumption that economic agents are rational beings making rational decisions we assume that the individuals who reported food wastage estimates offered rational estimates. Therefore, we conclude that the self-reported method gives the food wastage estimates depicting society's waste culture and is more representative due to its comprehensive nature.

2.3.2 Quantification Approaches

Experts opt for either the bottom-up approaches or top-down approaches to estimate and/or forecast food wastage. In the bottom-up approaches, scholars determine the food waste generation rates which is food waste per capita, household, country and crop and then expand it to the whole economy. These approaches are often used in global food waste reports predominantly brought out by non-government organizations, academic research institutes and interest groups, and have levels of detail that match the budgetary constraints and agenda of the publishing organization (FAO, 2013). However, this approach is more susceptible to double counting, obsolete data, purposive sampling and hiding a large degree of heterogeneity of food wastage per measurement unit, crop type and stages in the chain (Kaminski & Christiaensen, 2014).

On the other hand, in the top-down approaches, food wastage generated is assumed to be proportional to total production minus produced goods per sector in an economy. This approach is based on the concept that "all materials that enter the production process, either as raw materials or as intermediates, end up as produced goods or as residuals'' so that the growth rate of waste generated per sector can be less than the growth rate of production per sector(Bruvoll and Ibenholt (1997) , Reynolds,2013). This approach is more favoured in modern food wastage estimation since it overcomes the foreseeable flaws of the bottom-up approaches. Also, to minimize the incidence of double counting Kleigh et al (2013) suggest value-chain analysis. To relax the assumption of a one-to-one relationship between waste types and waste treatment methods Nakamura and Kondo (2009) developed Waste Input output table which is an extension Leontief's input output table. To overcome the hurdle of converting monetary waste data into physical data, Reynolds (2013) developed the Waste supply use table. Therefore, based on the desirable criteria of representativeness, the consideration of individual waste culture and the heterogeneous nature of food wastage, our study uses self-reported estimates of food wastage for the quantification method and the top-down quantification approach with value chain analysis.

2.3.3 Consistency of measurement

In the light of these varied approaches and methods, countries that produce their own reports on food wastage vary in the levels of based on the aforementioned costs of collecting waste data, conflicting jurisdictions and motivations over waste data publication by responsible national departments (energy, environmental protection, agriculture, etc.) (Kaminski & Christiaensen, 2014). These have led to the discrepancy between caloric and metric estimates of food wastage and the inconsistency of the estimates with agronomic studies. . For instance, in calories, it is estimated that 23% of food is lost in SSA (lipinski, et al., 2013) whereas in weight, 37% of food is lost in SSA (FAO, 2011). In both studies, the percentage share of food wastage of perishable crops such as roots and tubers and durable crop such as cereals in SSA is almost equal which is a sharp contrast to conclusions from agronomic studies that the higher water content in the former food groups make them more susceptible to losses/waste. Hence, as a form of cross-checking for validity and accuracy of the results, we compare the self-reported estimates used in this study to agronomy and a meta-study on cassava wastage.

2.4 Conceptual Challenges in Economic Analysis of Food Wastage

2.4.1 Analysing food wastage economically

According to Monier et al (2010) halving avoidable food waste throughout EU by 2020 will make Europe's food production-consumption system more resource efficient and increase global food security. However, since understanding real economic impacts of food waste reduction is different from translating one-to-one food loss reductions to input savings or output reductions, Ruten et al's MAGNET model (Rutten et al, 2013) attempted to model food wastage reduction as an increment in total factor productivity in a global CGE model. However, this models assumes food wastage as exogenous but food wastage is an endogenous component of the food production-consumption system in an economy. Thus, to endogenize food wastage, Irfanoglu et al. (2014) investigated the impacts of reducing global food loss and waste on food security, international trade, GHG emissions and land use by employing the partial equilibrium (PE) Simplified International Model of agricultural Prices, Land use and the Environment (SIMPLE).

The SIMPLE model introduced two new dummy production sectors, namely 'post-harvest sector' and 'household production' sectors. The former uses crop and livestock sectors together with a dummy input called postharvest input while the latter employs household labor and household food purchases. However, the problem with this method is that in developing economies the agriculture sector is so significant that changes in the supply and demand in that sector has spill overs in other sectors of the economy which will be ignored using this method. Furthermore, in the SIMPLE model, food wastage is defined as the difference between household food purchases and household food production which includes unavoidable food waste and food surplus required for household food security. Although the SIMPLE model's concept of endogenising food waste is useful for this current study, the approach used in both studies to reduce food wastage does not allow for separate treatment of avoidable food wastage.

2.4.2 Including Food wastage reduction costs

To address the reduction cost issues in the aforesaid literatures (Britz, Dudu, & Ferrari, 2014) uses a modified regional CGE EU model to assess the economic impact of food waste reduction in the EU on the global economy while considering three reduction cost levels. To simulate the food wastage reduction scenario, the authors suppose that if food supply chain agents increase their use of labor, land and capital, their unit cost of production and food price increases which forces agents to reduce food waste. This scenario is applied in the three different reduction cost levels; free lunch, tit-for-tat and expensive. Food waste reduction costs identified by the authors include investment to change or improve technologies and packaging, time dedicated to cook at home and producer's loss due to reduction of food demand. From this, the author concludes that if food waste reduction costs are not considered, the country or region that embarks on this policy shock may lose competitiveness.

2.4.3 *Considering the full cost of food wastage*

Britz, Dudu, & Ferrari(2014) and FAO (2013) estimated that food wastage costed about USD 936 billion per annum using general equilibrium analysis. However, FAO's full cost accounting report (2014) critiqued the estimate as one that does not account for the 'full cost[13]' of food wastage nor the full food life cycle. Consequently, FAO (2014) , using full-cost accounting(FCA) estimated that the about one-third of all food produced for human consumption that is lost or wasted amounts to about USD 1 trillion economic costs annually based on the assumption. In addition, FAO highlights that literature considering the costs of food wastage reduction should endeavour to include environmental costs and social costs of food wastage in order not to erroneously conclude that it is more profitable to throw away food.

Nonetheless, contemporary economists suggest that waste is not only a subjective practice but also it generated along the whole product supply chain from production to disposal (Reynolds, 2013). Hence we assume that the economic value of waste varies across the supply chain, value chains and food life cycle by the net benefit it would have accrued if not wasted. Also, FAO's study did not account for the fact that optimal food wastage is higher than zero. Thus although this latter estimate of the value of food wastage may be ideal for total food wastage, it does not consider that not all food wasted is avoidable. However, in our study we used FAO's estimate as a proxy for the waste collection fee since that is closest to the value of food wastage collected by this sector based on the assumption that the sector collects all the food wastage from the production-consumption supply chain agents.

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[13] social, environmental and economic

2.4.4 Considerations for The Food wastage Fixed Price Multiplier Model and

Based on these definitions, we propose that the economic structure of the food system be extended from the simple case, where food wastage was not considered, to the sustainable case which includes food wastage and the treatment of food wastage illustrated in appendix a part 3. Therefore, the Food System boundaries for analysis encompass:

- **The whole supply chain from production to food waste treatment:** agricultural production – storage, food trade - transport, distribution - consumption – waste collection (wastage stage)- waste treatment
- **Inputs per supply chain**: This includes all inputs to agricultural production, such as land, fertilizers or pesticides, or inputs to refrigeration storage or transportation, such as electricity. However, labor, capital and land inputted for food waste management sectors is assumed to be embedded in the net benefit used in pricing food wastage.
- **Outputs**: This consisted of food, gross food waste, waste treatment products such as feed, compost, etc. and net food wasted from the waste treatment sectors. Environmental products such as pollution are left for further study since only economic costs were considered.

Chapter 3: Theoretical Framework and Methodology

In this chapter we explain the empirical approach, source of data, theoretical framework and the methodology adopted for the study. The chapter concludes with a summary of the methods, data and approaches selected.

3.1 EMPERICAL APPROACH

In analysing the socio-economic impact of waste management in Ghana, there exist two dominant ontological perspectives; positivism [14] and interpretivism [15] (Baabereyir, 2009). Quantitative methods[16] are employed based on the positivist's ontology and qualitative methods[17] are employed based on the interpretivism, modern research resort to a combination of methods. Quantitative research methods are criticized for the assumption of equality between correlation statement and causal statements, sampling bias, measurement errors and the elimination of social and cultural influences on the results (Baabereyir, 2009). On the other hand, qualitative research methods are criticized for being small-scale and non-representative leading to lack of generalization beyond the cases investigated. It is also critiqued on its lack of objectivity due to its emphasis on personal opinions to support arguments and its openness to unconscious or conscious researcher's manipulation.

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[14] The positivist's ontology suggest that 'objective knowledge' is possible and thus resort to numerate or sense-experience data that is tainted by the subjective thoughts of the researcher or the researched using questionnaires, social surveys and experiments

[15] interpretivism regards 'reality as a complex social construction of meanings, values, and lived experience' which can only be comprehended by the subjective interpretations of the researched and the researcher 'using qualitative data obtained through the interpretations people give to their situations and experiences of reality using observations, interviews, documents and audio-visual materials which generate data mostly in the form of words'

[16] Quantitative methods are usually structured and deductive in nature, formulate competing explanations using the relationships between key variables.

[17] qualitative research involves the interpretation of data whereby the researcher analyses cases in their social and cultural context over a specific period of time" and may develop theories that emphasize tracing process and sequence of events in specific settings

In modern research, methods of quantitative and qualitative approaches are used to complement each other in a single study of social phenomena to improve the chances of getting better, more reliable data and to minimize the chances of biased findings. In conformity with Barbeyir (2009) that 'no single method (such as questionnaire, interviewing of documentary analysis) could completely capture all the relevant features of the study', we use the mixed methods approach by complementing hard data on the food wastage situation in Ghana with data from documentary analysis.

3.2 DATA ASSESSMENT

3.2.1 Food Wastage Quantum

Based on the most currently available data that fulfils the requirements for the definition and quantification of food wastage concluded in chapter 2 and the model used for this study, we assume the base period for the study to be the year 2005. Thus, this study assumes the Ghanaian economy has not undergone significant structural changes since 2005. Also, this study uses the cassava percentage shares estimated by Naziri et al (2012) and the estimate of cassava production in 2005 from FAOSTAT as the proxy for actual food wasted or lost in the study area which is cross-checked with agronomic perspectives of cassava wastage and a meta-study by (Affogon, Mutungi, Sanginga, & Borgemeister, 2015). Since these food wastage shares represent the avoidable food wastage only, this allows our wastage policies to be directly applied to avoidable food wastage without erroneously including unavoidable food wastage[18]. Also, we assume that cassava wastage is the only food wasted in the economy.

Similar to Reynolds(2013), we estimated the price of cassava wastage along the FCR value chain at producer prices at the production-wastage stage and selling prices at the consumption-wastage stage using (GSS & IFPRI, 2007) since that is the direct economic cost accrued by the supply chain agents at those stages. In addition, along the cassava value chains, GAR and AGB, we used the net benefit of processing fresh cassava roots into gari and agbelima estimated by (Wilhemina, Gayin, & Plahar, 2009). This is because we assume that the cost of food wastage is not only the fresh cassava roots lost but also lost value added which would have been accrued if food was processed. The net economic cost of food wastage of roots and tubers in SSA at zero waste estimated by FAO (2014) was used as a proxy for this fee since that is value of supply chain agent transferring all their food wastage to be ' food wastage-free'. At the waste treatment stages, food wastage prices is value

[18] Note that the Kokonte and farmers own consumption value chains are deleted since no wastage is generated from these value chains

added by the net benefit of wastage treatment method and the economic cost of food wastage respectively ((Analgate & Rahmaputro, 2014)) ; (Galgani, Vander Voet, & Korevaar, 2014)). These considerations are made in our study because if not both factors influences an upward adjustment on the costs of food wastage. These studies were used because they were the most current, reliable and publicly available data.

3.2.2 Social Accounting Matrix

Social Accounting Matrix (SAM) is an accepted extension of Leontief's Input Output (IO) table used to express economic structure of an economy for both economic and environmental analysis which is in the form of a square matrix with six types of accounts each having its own row and column: the activities, commodities, and factors (labor and capital) accounts; the current accounts of the domestic institutions, divided into households, firms, and the government; the capital account; and the rest of the world account (ROW) (Breisinger, Marcelle, & Thurlow, 2010). However, whereas IO tables describe the flows of goods and services through the forward and backward linkages between these sectors[19], the SAM include the forward and backward linkages between institutions[20] and sectors. However, it is based on the assumption that income elasticities are equal to 1. Further disaggregation of the institution accounts allows for the relaxation of this assumption. The SAM accounts are set up so that the row (receipts) and column (expenditures) totals are equal.

Nevertheless, waste analysts prefer IO tables to the SAM due to the SAM's requirements to express waste data in monetary terms (Reynolds, 2013). However, the SAM offers the option to perform further analysis on the impact on institutions by considering the interaction of these waste sectors with the institutions in the economy. Also, more complex models that allow for the analysis of more policy shocks use SAM databases but because the current SAMs do not account for food wastage separately, previous studies, assume that food wastage is endogenously generated as a difference between sector purchases and sector intermediate demand or as an exogenous reduction in production which can erroneously include food surplus meant for food security and unavoidable food wastage in policy analysis.

Motivated by Reynolds (2013), we suggest that expanding the number of sectors and entries in the SAM to include the wastage collection and treatment sectors as well as the cassava waste types

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[19] Sectors are responsible for the production of commodities and the intermediate demand of commodities for productions

[20] Institutions finally demand what is produced and provide factors such as land, capital and labour for the production of those goods.

enhances the partitive and holistic accuracy of the target analysis where a partitive accurate table will ensure a holistically accurate one but the vice versa is ensured via the removal of less relevant parts without significant change to the estimates for multipliers. By so doing, we expand the economic frame of previous general equilibrium models to consider the full life cycle of food and the food value chains which was ignored by previous national accounting frameworks. Therefore, we modified the 2005 Social Accounting matrix 2005 (SAM)[21] developed by the International Food Policy Research Institute and the Ghana Statistical Services under the Ghana Strategy for Support Program for Ghana's economic structure in 2005 (GSS & IFPRI, 2007) to create the full food life SAM.

3.2.3 The Food Wastage Inclusive SAM

First we aggregated the original SAM comprise of 6 activity, 6 commodity, 1 factor-labour , 2 factor-capital , 2 household, 1 capital, 1 government and 1 rest of the world accounts. In addition, we divide the household institution account into the cooking sector (Hcook) and the final demand institution for rural and urban households as well as introduced a new commodity account, cooked food. Hcook, which is untaxed, uses cooking labour (lab cook) and intermediate demand from food producing sectors and transforms these inputs in combination with other inputs namely energy and outputs from manufacturing sector to produce cooked food and gross food waste. Cooked food is finally demand by urban and rural households and Gross food waste is finally demanded by the waste collection sector. The part of the intermediate demand from the cassava sector which is saved or used to produce cooked food was estimated as the difference between the original total final demand and the estimated cassava wasted at the retail/consumption stage. Thus, contrary to previous studies, the study assumes that the household intermediate demand for food includes the food surplus used to safeguard against household food insecurity. Thus, total household demand is endogenize and is the sum of intermediate demand for cooking and food waste.

Since better than IO tables, SAMS allows the integration of income and consumption patterns into economic analysis by using data from household surveys**,** we used the data from Ghana's living standards survey (GSS, 2008) and 2009 Ghana time-use survey (GSS, 2012) to expand the labor account to include labor used in cooking (Labcook). The 2009 data was used because it was the first and only time use data available for Ghana. Assuming that, income from cooking was untaxed and that work time includes leisure time we derived the total time identity, total time equals work time plus cooking time. Based on this identity, the trade-off between cooking income and labour income

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[21] The original SAM includes 70 accounts (56 production activities producing 59 commodities) The details of the accounts in the original SAM is outlined in appendix B-Part 3 ,table 6 labelled FWSAM-B

was assumed to be one-to-one since household's total time can only be spent on work or cooking food. Hence, we estimated Labcook income= Labwork income*(labcook time/Labwork time). That is, we first calculated share of these activities in total household time use and then valued them by the country's wage rate in the base period. Thus, household labor endowment are sourced from work labour and cooking labour. The work labour is supplied by households to the production sectors and cooking labour is supplied to the household cooking sector.

Furthermore, we introduce the cassava wastage stage into the SAM by extending the SAM to include cassava waste types accounts. This database allows us to assess the contribution of food wastage to the economic structure of Ghana. To produce the commodities, the cassava sector, trade and transport sector and the local food processing sector intermediately demand regular commodities which include fresh cassava roots, factors of production and waste collection services to produce commodities. Now, part of the fresh cassava roots intermediately demanded is lost along the cassava value chain. Therefore we enter the value of avoidable food loss across the respective supply chains and value chain into the waste type's accounts, FCR, AGB and GAR. Also, food waste generated by household cooking sector along the value chain is entered in this same account. Since the food wastage shares represent the avoidable food wastage only, this modification allows food wastage policies to be directly applied to avoidable food wastage without erroneously including food surplus saved or stored for food insecurity purposes or wrongly assuming that unavoidable food wastage is preventable. In both cases, we endogenize the total intermediate demand, which is the sum of the intermediate demand used in the production process and the intermediate demand lost or wasted. Therefore, food waste is generated by the cooking section of household and food loss is generated by the cassava sector.

We introduce a food wastage collection sector (wcollect) to finalise the creation of the food wastage inclusive SAM labelled FWSAM-B in appendix B Part 3. Food is wasted/lost in the cassava sector, transport sector, local food processing sector and the household cooking sector along the value chains which is intermediately demanded by waste collection sector in exchange for payment for the waste collection service. The waste collection sector then supplies the food wastage generated to the waste treatment sectors at a value added price. So we vary fresh cassava roots wastage by the cassava value chain ((i.e. FCR, GAR, and AGB) contrary to Reynolds (2013). Note that KOK and FOC value chains are deleted since no wastage is generated from this value chain per the wastage shares collated by Naziri et al. We assume that the unmentioned sectors do not use the waste collection service since they do not incur any food wastage. Thus, FWSAM-B include 8 sectors, 7 commodities, 4 factors, 2 household accounts, 1 waste collection section, 3 waste types, 1 government account, 1 capital account and 1 rest of the world account(see appendix B part 3).

3.2.4 The Full Food life SAM (FWSAM-C)

We further extend the FWSAM-B to FWSAM-C, a where food wastage can be treated via waste treatment methods to produce new products and/or new waste. The waste treatment methods considered include prevention, reuse via food banks or gifts, recycle via composting, e-disposal via engineered landfills and gas generating incineration, recovery via anaerobic digestion and illegal dumping. We chose these treatment methods because per documentary analysis these were the treatment methods under consideration or in use in the country. We assumed that food wastage is prevented via the waste prevention vector and if not prevented it is re-allocated for treatment using the other methods via the waste treatment allocation matrix. With the exception of the prevention method, all other treatment methods were introduced into the SAM as an account. The prevention method was introduced into the SAM as a multiple of all the food wastage accounts. In the baseline case, it is assumed that 100% of food wastage is illegally dumped with the assumption that traditional landfill and illegal dumping are synonymous. Therefore, the full food life SAM, comprises of 34 accounts (see details on accounts and its general framework in part 3 of appendix B). Its general framework is given as:

Table 2 Accounting identities of the Full Food Life SAM

Identity type	Components and output	Mathematical Expression	Legend of variables
Total production identity(X1)	gross input =Gross output production-to-wastage stage output: regular commodities food wastage	(Z21+V31+W51+W61)= (X12+W15+W16)	Z21 = intermediate demand of comm by sec (this represents part of total intermediate demand that is used in the production of commodities) V31= Value added demanded by sec for production of comm W51= waste collection services demanded by Sec
Regular supply-demand identity(Z2):	Total supply = total demand	(X12+W52+F82) = (Z21+W25+C24+F28)	W61= Intermediate demand of food wastage from wtyp by sec (this represents part of total intermediate demand that is lost or wasted)
Gross food wastage production	Total food wastage input= Total food	(W15+W25) = (W51+W52)	X12= Domestic supply of comm to

identity(W5):	wastage output		sec
	waste collection stage output = food wastage + waste collection services		W52= domestic supply of comm to Wcollect F82= imports, taxes and tariffs on comm paid to Inst.
Food wastage supply-demand identity (W6):	Total food wastage supply = total food wastage demand	(W16+W76) = (W61+W67)	V43= factor payments to household =sum gives the GDP at factor cost V3= factor expenditures W15= waste collection service payments to Wcollect by sec
Waste treatment identity (W7):	Total Wtreat input = total Wtreat output So the output at the waste treatment stage =net waste + new products	(W67) =(W76)	W25= Food loss and food waste supplied by fresh cassava roots and cooked food to Wcollect W16 = Food wastage supplied by sec W76= Net waste and New products supplied by Wtreat
Household Income-expenditure identity (Y4):	Household expenditures =Household incomes	(C24+S84)= (V43)	W67= Net waste and New products intermediately demanded by Wtreat C24= final demand of comm by households (does not include food wastage)
Institution income-expenditure identity (E):	Total Inst expenditures = total Inst incomes	(E) = (F82+S84)	S84= part of household income saved or transferred to other institution accounts

3.3 Theoretical Framework

For a more integrated approach to economic efficiency, modern economics promote Pareto efficiency. This concept states that an economic equilibrium is only optimal if no individual can be made better off without making someone else worse off; based on the identities, marginal resource cost=marginal revenue product and marginal rates of substitution= marginal rates of transformation. In this case, production must match what the consumer wants. This alludes to the first fundamental theorems of social welfare which states that perfect competition market equilibrium yield Pareto efficient outcomes. Based on this, economists identified that imperfect market structures, factor allocation inefficiencies, market failures price discrimination, asymmetric information and government failures may lead to economic inefficiencies. This is because many consumption-production mixes can yield pareto-efficient results which are not socially desirable. Market failures such as information asymmetry, non-competitive markets, public goods and externalities in the simple commodity market creates allocation inefficiencies in an economy which requires government policies to fix these distortions. (See appendix B part 2for examples of food wastage related policies in OECD countries).

Table 3 Types of Government policies that target externalities

Policy type	Description
Pigovian taxes or subsidies	This is intended to redress economic injustices or imbalances.
Regulation	These are used to limit activity that might cause negative externalities
Government provision of services with positive externalities	These include recycling plants, composting plants, food banks, etc.
Lawsuits	These are used by affected parties to get compensation for negative externalities
Mediation or negotiation	This is an agreement between those affected by externalities and those causing them.
Appeal for behavioral reforms	These include mass education to appeal to consumers or other supply chain agents to use or create food sustainably.

To determine socially desirable Pareto efficient outcomes, economists proposed the second fundamental theorem of social welfare which states that any Pareto efficient outcome can be supported as a competitive market equilibrium. Thus, if a more Pareto efficient outcome is identified, economic agents can agree on a set of prices (or a set of quantities in the fixed price case) as the new equilibrium for the economy. The second theorem allows for public policy interventions to fix economic inefficiencies. Based on this, the concept of allocative efficiency argues that if every good and service is produced up to a point where the last unit provides a marginal benefit to consumers equals the marginal cost of producing it then goods and services have been allocated efficiently. These are used in assessing the impact of public policy on society and its sub-groups in welfare analysis since the concept supposes that every public policy intervention yields wins and losses whose beneficiaries can be identified, quantum can be measured and re-allocated to maximize net social benefit of the intervention.

Since a food wastage policy shock that shifts the equilibrium in the cassava commodity market can affect the supply and demand in other markets such as the labor market, processed goods market, capital market, etc. due to the interlinkages between sectors in the economy, for macro-level welfare analysis on public policies, general equilibrium theory is employed. According to this theory, there exist a socially acceptable Pareto efficient general equilibrium for which there is optimal amount of food wastage. Hence, relevant policy interventions is needed to move markets to this equilibrium which will imply a close to optimal allocation of resources throughout the economy and result in a sustainable pattern of production and consumption. So, in the baseline case we assume that the current cassava wastage in the cassava export driven economy is not optimal. So that, minimizing (food wastage in the cassava sector) subject to (food wastage treatment costs) moves this economy to this new general equilibrium that has more socially desirable avoidable food wastage.

3.4 Methodology

3.4.1 Comparison of General Equilibrium Models

Based on the SAM, models that can be developed for policy simulations include the computable general equilibrium model and the fixed price multiplier model (GSS & IFPRI, 2007). For these policy simulations the SAM is usually divided into endogenous[22] and exogenous accounts[23]. Compared to the CGE models, traditional fixed price multiplier models cannot take account of behavioural reactions which include non-market clearing, imperfect completion, non-price demand influences and price effect because it assume a Leontief technology of fixed technical coefficients, fixed prices and unitary income elasticities so that exogenous changes in demand only affects income by a

[22] The account is called endogenous when changes in the level of expenditure follow directly any change in income

[23] exogenous accounts the expenditures are set independently of income

multiple (Breisinger, Marcelle, & Thurlow, 2010). However, since CGE models require accurate and up-to date exogenous elasticity estimates which is currently lacking for food wastage, the fixed price multiplier model was desirable. More so, since CGE models are driven by price effects which are assumed fixed for the fulfilment of the purpose of this study, CGE is less desirable in this case.

Alternatively, Partial equilibrium analysis, proposed by Irfanoglu, Baldos, Hertel, and van der Mensbrugghe (2014), examines the effect of a policy shock in one sector by assuming that effects on other sectors will have little impact. However, since the food system is integrated in three-to five sectors when the whole supply chain and value chain is considered and considering that Ghana, like other developing countries, is agro based, policy shocks applied to food wastage will have spill over into other sectors due its significance in those economics, making this method of analysis less desirable for this study. The multiplier model assumes that changes in demand will lead to changes in output and not prices. Thus, the model is appropriate for economic analysis of the quantity effects of policies void of price effects which is a desirable feature for this study's scope. Hence, the fixed price multiplier model was desirable for this study.

3.4.2 The Fixed Price Multiplier Model

The traditional fixed price multiplier model is a demand driven model. However, the basis of the cassava wastage reduction is that as the demand efficiency of the cassava sector, local food processing sector, trade and transport sector and household institution improves through technological or behavioural changes in its food wastage. Consequently, the production of food wastage decreases while the related food production should increase in a static model since there is a one-to-one inverse relationship between the generation of food wastage and regular food output (Reynolds, 2013). Further on, we critique the food wastage reduction simulation proposed by the previous computable general equilibrium studies to be synonymous to 'robbing Peter to pay Paul'. In that, by assuming that expanding the factor share of land, which is limited, and other factors used in general food production would force a reduction of food wastage they assume that if resource efficiency is worsened , food production declines and thus food wastage is reduced which is contrary to the sustainability perspective of food wastage reduction. This mix-up of food wastage treatment with food treatment is because previous literature mash up the food wastage and food wastage treatment stages with other food supply chain stages or erroneously assume that the technology used to produce food is the same technology used to treat food wastage (Reynolds, 2013). Therefore in our study, food loss reduction is applied directly to the wastage available in the economy which in turn increases the supply of food and reduces the technical coefficients of food wastage generation. Similarly, food waste reduction is applied to the household cooking sector.

In an input-output analysis, Reynolds suggested that the contents of waste treatment allocation matrix is determined by economic, technological factors, which when altered can better be used to depict shifts in the behaviour of economic agents than the exogenous change in final demand. Thus, similar to Reynolds (2013), we adjust the content of the waste treatment allocation matrix to depict the change in technology or behaviour of supply chain agents to depict the waste treatment policy shocks. Contrary to Reynolds, we do not include prevention in waste treatment allocation matrix but in a separate waste treatment vector. This is because, ideally waste that is prevented do not get to the waste treatment stage but revert to the production-consumption stages as explained in the sustainable food system in appendix A part 3. Therefore, for the fixed price food wastage multiplier model, we assume that the food wastage technical coefficients is alterable exogenously using a waste prevention vector or food wastage treatment allocation matrix which is more 'close to reality'.

More so, the traditional model does not consider the profitability or feasibility of a policy. Thus, to offset this limitation, we consider the net benefits of the policies as prices of the cassava wastage treatment services. Furthermore, an unconstrained increase in food wastage reduction may overstate the outcome of the intervention since in reality the supply of sectors are not infinitely elastic. Hence, the study considers only the case when policy are implemented subject to constrained cassava supply. This is a relevant characteristic since this study acknowledges that food production is limited by the scarcity of natural resources such as land, water, etc. However, the model is a fixed-price static model with unitary demand and supply elasticities. Thus, for further analysis the elasticities of demand and supply in the food wastage sector and the price transmission can be explored.

Therefore, for the purpose of this study, we modified the traditional model to create the Fixed Price Food Wastage Multiplier model. This model answers the question what is the economic impact of a certain exogenous change in the gross cassava wastage produced via a waste prevention percentage OR in the gross cassava wastage intermediately demanded by waste treatment sectors via a waste treatment allocation matrix subject to a certain level of waste treatment cost when there is an exogenous increase in the export demand of the cassava sector. Contrary to this, a traditional model based on SAM basically answers the question, what is the economic impact generated by a certain level of exogenous expenditure. Kindly refer to table 10 for modifications made in the assumptions of the traditional model for the modified model (in appendix B part 4).

3.4.3 The Fixed Price Food Wastage Multiplier Model

To create the model based on the SAM, we first separate the SAM accounts into Exogenous and Endogenous accounts (which represent the endogenous and exogenous variables of the model) as follows:

Table 4 Identification of variables in the Fixed Price Food Wastage Multiplier Model

Policies	Endogenous variable[24]	Exogenous Variables[25]
Policy Variables(shocks): 1. Cassava wastage Prevention Policy 2. Integrated Cassava wastage Management Policy 3. Cassava export Policy 4. Combined Policy	Policy objectives or target variables: 1. Total Output (X1) 2. Food security (Value of physical food available)= Gross Output (Z2) 3. Food Wastage footprint= Gross food wastage output (W5) 4. Net Waste generation= Waste treatment Output (W7) 5. Household Income (Y4) Employment(Value added labor)-part of V3 Economic growth(GDP at factor cost)- V3 Other Endogenous variables: 1. Food wastage demand 2. Leakages[26]	Policy Instrument Variables[27]: 1. Waste prevention vector (gr) 2. Waste treatment allocation matrix (S67, g7) 3.Cassava export demand from rest of the world (E) Other Exogenous variables28: 1. Final demand of government account 2. Final demand of Savings-Investment accounts.

Using matrix algebra, the system of equations underlying the model and the solutions of the model are derived as:

Table 5 Mathematical Expression of the model

The Model	Solving the Model	Legend of coefficients	Solutions
Total demand-Total Supply (1): Z2=aX1+g2W5+cY4 +(E*B)	Express X1, W5 and Y4 in terms of Z2, Put (5) into (4):	**a** is input coefficients (i.e., input or intermediate shares in production) **v** is the share of value-added or factor expenditure in gross output	**1. Z2=** A*E*B Where A= ((I-

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[24] the values of endogenous variables are determined by the economic model

[25] the values of exogenous variables are determined outside the model

[26] [26] Exogenous accounts also receive payments from endogenous accounts. These payments are considered as Leakages, as they exit the endogenous part of the economic system and do not contribute to the multiplicative process described. The leakages are row entries of the exogenous account. Expenditure from exogenous accounts are the column entries of the exogenous account.

[27] These are variables which can be directly or indirectly manipulated by decision makers and which enable policy measures to be driven inside the model

[28] These are made exogenous because they are less significant to the study

Where, E= vector of original Final demand by institutions B = exogenous change in exogenous accounts= vector of shocks **Gross output (2):** X1=BZ2+g3W5+g1W6 **Gross Food wastage output (3):** W5=g4X1+g5Z2 **Gross Food wastage demand (4):** W6=g6X1+S67W7 **Gross waste treatment output (5):** W7=g7W6 **Income-Value added identity (6):** Y4=V3=vX1 **Leakages (7):** E*B=LZ2+ sY4	W6= R* X1 -------**(A)** Where R = ((I-S67g7)^(-1))*g6 Put (A) and (3) into (2): X1= T*Z2 ------**(B)** Where T= (I-(g3g4+g1R))^(-1))*(b+g3g5) So that (A) becomes: W6= R*T*Z2-----**(A2)** Put (B) into (6) : Y4 =v*T***Z2** -----**(C)** Put (B) into (3): W5= (g6*T*Z2)+(g5*Z2) =(g6*T+g5)Z2 -------- **(D)** Put (B), (C) and (D) into 1: Z2= (M*)*Z2) + E*B where M*= a*T+ g2*(g6*t*g5)+ c*(v*T)	**gr** is the Food wastage prevention vector (the percentage of food wastage prevented) **g4** is the share of waste collection services expenditure of total production **g6** is the gross food wastage share of total production **b** is the share of domestic supply in total supply **g5** is the share of waste collection services of total supply **L** is import rate or commodity tax rate (the share of imports or commodity taxes in total supply) **g3** is the waste collection rate (waste collection services share of total wastage production) **g2** is the food wastage rate (food wastage share of total wastage production) **g1** is food wastage share of total food wastage supply **g7** is the new products and net waste share of total food wastage supply **S67** is the waste treatment allocation matrix= share of food wastage allocated to waste treatment method **c** is household consumption expenditure shares **s** is the household savings rate (i.e., savings as a share of total household income)	M*)^(-1)) = Matrix of SAM multipliers **2. X1=** T*Z2 **3.W5=** (g6*T+g5)Z2 **4. W6=** R*T*Z2 **5. W7=** g7*W6 **6. Y4**=v*T*Z2 7.E*B= (L+(s*v*T))*Z2

This Matrix of SAM multipliers enables the effects of exogenous demand to be transmitted to the economic system through a process of "multiplying" impacts which follow an iterative circuit of production and supply of regular commodities, food wastage, new products and net waste as well as the use of income. After the, the exogenous shock, or "injection", is applied by a change in elements of the exogenous ROW account, the waste prevention vector and/or the waste reduction vector, the model solves for the equilibrium level of all the endogenous accounts. So that, the multipliers are demand, wastage generation and waste treatment allocation driven.

3.5 Summary

In this section, table 5 summarises the conclusions of the sections and table 6 provides the description and the analysis procedure used for the policy shocks based on the conclusions in table 5.

Table 6 Summary of Theoretical Framework and Methodology

Section	Conclusion
Empirical Approach	Mixed methods approach

Data Assessment	Base year=2005 Food wastage quantum: Value chain analysis (Naziri, et al., 2014) Value of food wastage at Production-Wastage stage: Food wastage in the FCR value chain is valued at the producer and selling prices (GSS & IFPRI, 2007) Food wastage in the AGB and GAR value chains is valued at the net benefit of processing fresh cassava roots (Wilhemina, Gayin, & Plahar, 2009) Value of food wastage at Waste collection stage: Value added to food wastage is estimated as the net benefit of being food wastage free (FAO, 2014) Value of food wastage at Waste treatment stage: Value added to food wastage is estimated as the net benefit of using treatment method to treat waste (Analgate & Rahmaputro, 2014); (Galgani, Vander Voet, & Korevaar, 2014) Economic structure: 2005 Ghana SAM (GSS & IFPRI, 2007). This is modified to create the Full food life SAM which includes the waste collection sector, the waste types, waste treatment sectors, cooking labor, household cooking sector and cooked food.
Theoretical Framework	General equilibrium theory In the baseline case, we assume that the current cassava wastage in the cassava export driven economy is not optimal. So that, minimizing (food wastage in the cassava sector) subject to (food wastage treatment net benefits) moves the economy to this new general equilibrium that has more socially desirable avoidable food wastage.
Methodology	The fixed price food wastage multiplier model. The traditional fixed price multiplier model is extended to be not only demand driven but also wastage prevention and wastage treatment allocation drive. This is a constrained multiplier model.

Table 7 *Policy Shocks*

Shock	Description	Procedure
Shock 1: Cassava Export policy (Baseline)	A 50% exogenous increase in export demand by the rest of the world from the cassava sector in the 2005 forward	Enter 12.41 in the exogenous shock vector (E).

In this baseline case, we assume that all wastage is disposed via illegal dumping.	contract equivalent to 12.41 billion cedis.	
Shock 2: Cassava Wastage Prevention policy (cassava waste reduction + export)	A 50% exogenous reduction in total fresh cassava wastage via technological changes in the pre-retail stages and behavioural changes in the retail/consumption stage in an economy driven by 50% exogenous increase in cassava export demand.	Enter 0.5 in the waste prevention vector (gr). This alters the technical coefficients for the food wastage. Apply shock 1.
Shock 3: Integrated Cassava wastage Management policy (integrated cassava management export)	The integrated cassava wastage management policy refers to case where 66% of the waste is equally reallocated to waste treatment methods and 34 % represent uncollected waste which are illegally dumped. The equal waste allocations is feasible for all the treatment methods since the most demanding treatment method, disposal, requires only 270,000 tons of total solid waste[29] to produce energy ((Analgate & Rahmaputro, 2014)).	Multiply 0.34 by the value of total food wastage supplied to waste treatment methods in the illegal dumping row. Sub-divide 0.66 by 0.25 for the other waste treatment methods and multiply by the value of total food wastage supplied to waste treatment sectors in the respective waste treatment row Apply shock 1
Shock 4: Combined Policy (Wastage Prevention + Integrated Wastage Management+ Export)	In this last stage, we consider a case where 50% of cassava wastage is prevented and the other 50% is allocated to the waste treatment sectors given an exogenous increase in export demand by 12.41billion GHS.	Do the procedure in shock 3 and shock 2 simultaneously. Apply shock 1

[29] Organic waste is 66% of solid waste which implies that disposal method(specifically engineered landfill) requires less than 25% of total wastage to generate energy

Chapter 4: RESULTS AND DISCUSSION

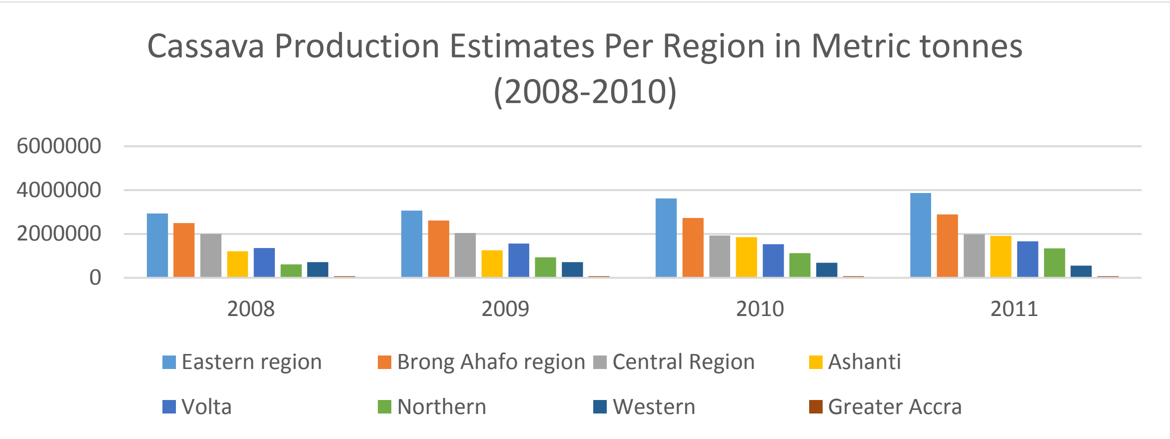
The chapter begins with the results from the documentary analysis on the cassava industry in Ghana in section 4.1 which addresses the first research objective. In section 4.2, we present and discuss the results of the economic impact of the policy shocks which addresses research objectives 2 and 3. The chapter ends with a conclusion which gives the answers to the research questions of the study.

4.1 THE CASSAVA INDUSTRY IN GHANA

4.1.1 Contribution to the Economy of Ghana

Cassava, *manihot esculenta,* is primarily produced for domestic supply as fresh roots or processed products in Ghana (Naziri, et al., 2014). The cassava sector of Ghana is estimated to contribute about one-fifth the country's agriculture GDP and 5.8% of the global cassava production in 2013; making Ghana the 7th world cassava producer in that year (FAOSTAT, 2005-2011)

Figure 1 Cassava Production Estimates in Metric tons per region per year (Source: MOFA/SRID 2012)



As a result, in recent years, the cash crop potential of cassava as High Quality Cassava Flour(HQCF) for the food processing industry, as glue extender in the plywood industry as well as improved chips/grits for animal feed industry and brewery industry is getting an increased acknowledgement in the country (Kleih, Phillips, Wordey, & Gregory, 2013). In addition, due to the potency of the crop to not only improve food security but alleviate rural poverty, FAO and IFAD embarked on the Global Cassava Development strategy with the sole aim to use to demand-driven food chain approach to promote and develop the cassava sectors and cassava-related sectors in some Sub-Saharan African countries which included Ghana. Although the strategy has greatly improved productivity over the years as illustrated above, food wastage is one of the key drawbacks of the success of the intervention (Naziri, et al., 2014)[30].

4.1.2 Breakdown of the Cassava Sector

4.1.2.1 Production

In Ghana, Cassava is produced in 8 of the 10 regions, but is particularly abundant in Central, Eastern, Brong Ahafo, Volta, and Ashanti regions, during the rainy season, May-September, and harvested 12 months after planting, March-October (see figure in section 4.1.1). Consequently, Cassava production represents approximately 50% of all roots and tubers production in the country. Cassava roots production has increased by almost 40% between 2007 to 2011 primarily due to an increase in average yield per hectare, from 12.76 to 16.17 tons per hectare, and an 11% increase in the amount of land under cultivation (Kleih, Phillips, Wordey, & Gregory, 2013). Also, it is estimated that about 90% of the Ghanaian farming population, mostly male smallholder farmers, participate in cassava production as an inter-crop (MOFA, 2012). The male-dominance is mainly because men are more likely to secure longer land tenures or own lands which is crucially relevant for the longer fallows and bigger land sizes required to increase cassava yield. Also, due to lack of credit facilities from financial institutions , since most poor or female cassava farmers lack collateral, farmers use their own savings which is often not enough to expand the 'business' and thereby increase yield (Coulibaly, Arinloye, Faye, & Abdoulaye, 2014).

Furthermore, despite Ghana's significant strides in cassava production, cassava exports are very minimal and the country is estimated to incur the highest physical and economic food losses in West Africa which threatens the cassava food security the country is 'seemingly' enjoying (Naziri, et al., 2014). This because contrary to production estimates, about 30% of fresh cassava roots remain in the ground unharvested due to insufficient demand, lack of buyers, or more likely weak marketing connections (Kleih, Phillips, Wordey, & Gregory, 2013). Also, most of the cassava produced reaches the consumers in fresh form and since the product only has a 2-day shelf life , majority of the food is wasted at the retail-consumption stage(Naziri, et al., 2014); (USAID, 2012). Although, Ghana has globally achieved a significant level of self-sufficiency in cassava availability for domestic consumption, these results are uneven within the country and like many of its crops, the country is slowly beginning to import cassava products to meet up with increasing consumer demand. For instance, 91.3% of cassava farmers in regional analysis of cassava value chains in Ghana stated that they do not produce enough food for the whole year and as a result 25.5% buy staple food, 11.4%

[30] See appendix for information on the historical development of the cassava sector in Ghana

borrow money for food or get food on credit, 34.4% reduce the number of their meal, 15.6% modify cooking method, 6.7% sell their assets and 16.7% borrow from their neighbours in order to feed. (Coulibaly, Arinloye, Faye, & Abdoulaye, 2014). Nonetheless, the cassava farming business in Ghana in itself is a profitable venture since a farmer could earn a profit of 54.51 US$; on average farmers spend 100.21 US $ per acre and sell the fresh cassava for 54.51 US$ per acre (Coulibaly, Arinloye, Faye, & Abdoulaye, 2014). Hence, reducing fresh cassava roots wastage in Ghana is imperative for the success of this sector and Ghana as a whole. The study also indicated that aside the fresh cassava roots, cassava leaves in Ghana are predominantly used for eating or as planting material (100%). So unlike in other African countries, cassava leaves and stems in Ghana are not usually sold as food on the market and are thus not considered in our study.

4.1.2.2 Processing-to-Retail

The bulk of cassava processing, which is by the informal sector, is characterized by local-to-local food processing[31] with a relatively minimum, about 1%, local-global food processing sub-sector which is normally industry based (Robinson, Kolavalli, & Diao, 2012). However, recent policies targeted at the cassava sector seeks to expand the local-to-global food processing dimensions. Although (IFAD & FAO, 2005) identified three potentials for commercial processing of cassava including partial substitution of cassava flour for wheat flour in bread, cookies and pastries and use in the beer industry, the large part of processors in Ghana continue to use traditional processing methods because the technology for processing modern industrial cassava products are often not available to most low income cassava producers and processors (Kleih, Phillips, Wordey, & Gregory, 2013).The processing of cassava for industrial starch came under the Presidential Special Initiative (PSI) on Cassava Starch but the factory was closed in January 2008 due to the impossibility to operate at its full capacity as farmers 'supplies of fresh roots reduced. Also, Ghana started to export chips for animal feed to Europe in 1994 when the EEC quota (140 000 MT in 1994) was given to African countries but this has dwindled due to the increase in quality standards by the companies (Kleih, Phillips, Wordey, & Gregory, 2013).

Traditional cassava processing though labor intensive and time consuming, controls deterioration of Fresh Cassava Root (FCR) and reduces the high cyanide content in FCRs. In Ghana, Cassava is processed into high quality cassava flour (HCQF), gari, Kokonte or agbelima and is easily fortified to provide additional nutritional value which is essential among the poor and vulnerable populace. E.g. Super gari in Liberia. When processed into gari, the shelf life is increased from 48 hours to 6 months.

[31] Processed for domestic markets

Also, gari is estimated to be the 'most promising' cassava processed products due to its favourable prices, high demand and income elasticity (Coulibaly, Arinloye, Faye, & Abdoulaye, 2014). The acquisition of mechanical graters during the last two decades contributed to an increase in the supply of gari in Ghana. (Kleih, Phillips, Wordey, & Gregory, 2013). Processed cassava products are then sold on the rural and urban markets in the country. Although urban markets offer better selling prices, Coulibaly et al (2014) found that 50% of processors prefer to sell their products on the rural market while 35.5% prefer to sell on the urban market and 7.1% to other households due to their distance from the market. In these markets, buyers include the small enterprises (35.7%), the National traders or retailers (21.4%), the large enterprises (14.3%) and the Government or public firms (7.1%). Similar to the cassava production sector, the cassava transport sector ,which plays the role of ensuring food produced on the farm get to processing markets,retail markets and exporters, are predominantly men but with higher education levels than the former. On the other hand, the processing and retailing subsets of the cassava sector in west Africa is female-dominated with about 56% having contracts with their retailer or clients but because of their low level of literacy 81.2% of these contracts are verbal and hence not very binding in most cases (Coulibaly, Arinloye, Faye, & Abdoulaye, 2014) (MOFA, 2012). Therefore, the cassava retail and possessing sectors holds promise for economic empowerment among rural women.

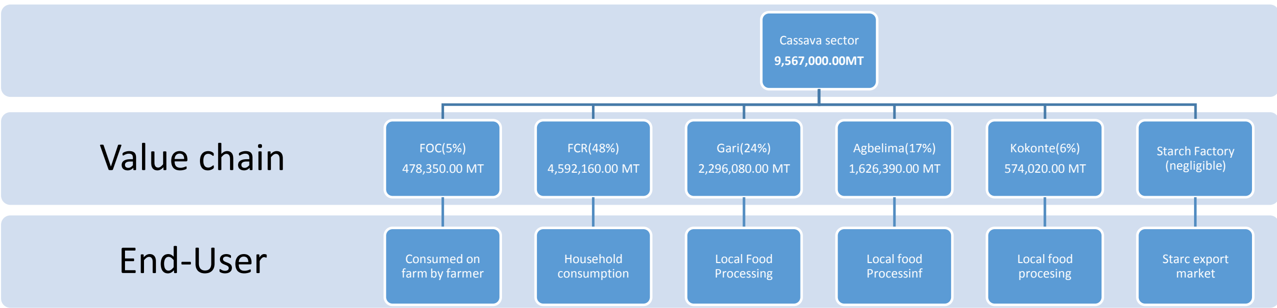
Financial services provider are mainly men and have a very good educational level of education. Results revealed that around 90 percent of them provide some of the cassava value chain actors (producers, processors, marketers) with credit. Whereas access to credit is one of the major setbacks for the processing and retail divisions of the cassava sector, over 50% of transport agents are estimated to have access to credit from financial institutions and moneylenders (Coulibaly, Arinloye, Faye, & Abdoulaye, 2014). Extension services provide actors with different services including trainings, extension advices and sensitization. They mainly diffuse technologies about production and processing (MOFA, 2012). Thus, the study considers these recent development by considering a scenario when cassava export policy is implemented with and without food wastage treatment policies.

4.1.3 Cassava Wastage in Ghana

4.1.3.1 Value chain Analysis of Ghana's Cassava Sector

Kleih, et al (2013) estimated that that of the fresh cassava roots produced, 5% is allocated to farmer's own consumption, and 48% is domestically supplied as fresh roots, 24% to gari processing, 17% to agbelima processing and 6% to Kokonte processing. (Naziri, et al., 2014) adopts the value chain analysis in this study because contrary to previous studies the study differentiates between farmer's own consumption and domestic supply for intermediate demand and household consumption as well as considers cassava sector in Accra, Tema, Kumasi, Takoradi, and Volta region (Ho and Hohoe) which is more representative nationally. Thus based on their results, (Naziri, et al., 2014) estimated that about 12.4% of cassava is lost annually due to weak marketing conditions and underdeveloped cassava value chains. In July and October 2012, a semi-structured questionnaire was used to collate data on core processes, traded volumes, prices and price mechanisms, seasonality, standards, types and major causes of losses, and information on loss quantities and mitigation measures for each cassava product from 145 value chain actors. (Naziri, et al., 2014).

Figure 2 The Allocation of Fresh Cassava Roots in the cassava sector in 2005



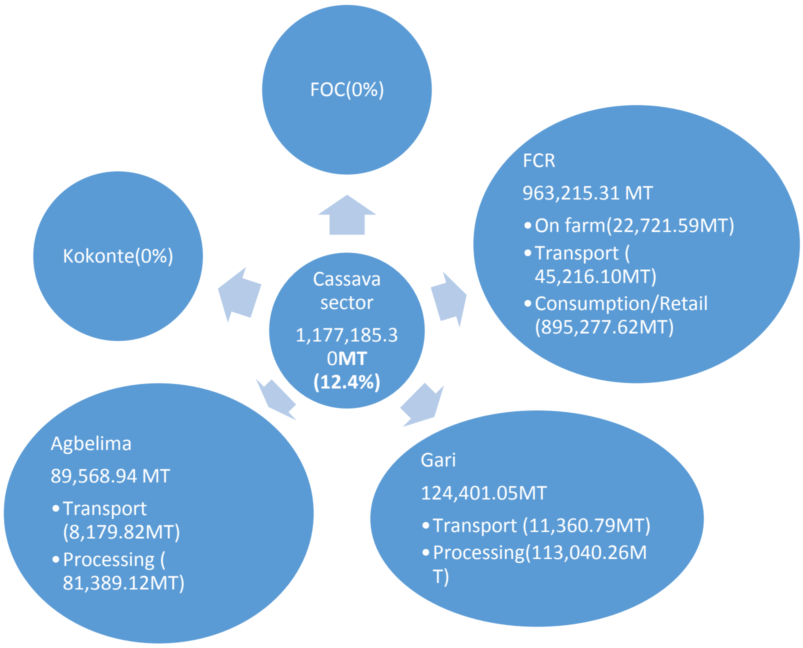
4.1.3.2 Quantification of Cassava Wastage

Drawing from chapter 2 and 3, the food wastage share estimates derived in Naziri et al (2012) study was preferred since it fulfils the desirable criteria of availability, representative of Ghana and makes a distinction between producer's own food consumption and domestic supply through the value chains (See appendix for previous studies on the cassava wastage quantum). In addition, the results is consistent with agronomic perspectives which indicate that fresh cassava roots are perishable within 48 hours of harvest. This because considering that it takes less than 48 hours for fresh cassava roots to be transported to urban and rural markets in Ghana and processing delays the perishability of the crop, it is only intuitive that fresh cassava roots at the consumption/retail stage are more (Kleigh et al, 2012).

To the best of my knowledge only one study has attempted to perform a meta-study on cassava wastage in Ghana due to the general lack of literature on food wastage in roots and tubers. This

Meta study by (Affogon, Mutungi, Sanginga, & Borgemeister, 2015) attempted to estimate the quantum of root and tubers wastage in Ghana. However, only 6.1% of the 213 documents used covered cassava and yam[32]. Using the means and SD of estimates, PHL losses for roots and tubers were estimated to be 43.5+/- 27.4%. Using the random effects model, which used only 21 studies[33] , they estimated that PHL losses for dried cassava chips as 45.52 +/-17.5%. The limitation of these figures are that they are not corrected for storage withdrawal and do not distinguish between other cassava value products and the fresh cassava product which could be the reason for the difference between our preferred estimate and this estimate. However, the study re-emphasised the difficulty in getting appropriate cassava wastage estimates and proposed that studies that consider the whole food supply chain and value chains will be appropriate which our selected study fulfils. Although cassava production has significantly increased from 9,567,000 tons in 2005 to 14,240,867 tons in 2011, the structure of the industry has not changed significantly (Kleih, Phillips, Wordey, & Gregory, 2013). Hence, this study assumes that food wastage percentage and chain shares in 2005 are not significantly different from that in 2011. Thus, fresh cassava roots and its wastage are allocated as follows:

Figure 3 Cassava wastage allocation using value chain analysis



4.1.3.3 Economic Value of Cassava Wastage

The prices of the cassava wastage at different levels of the food system is determined as follows:

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[32] 5 literature on cassava and 9 literature on yam in Ghana

[33] since85% could not meet statistical requirements of the random effects model.

Value chain	Price at production to consumption stage (GHS per ton)34	Price at waste collection stage35	Price at Recycle method36 and Energy Recovery method	Price at Disposal method37
FCR	488.84 (estimated as total value of cassava production in SAM divided by the total production in 200538	571	2937	599
GAR	600.0039	682	3048	710
AGB	700.0040	782	3148	810

4.2 ECONOMIC Analyses of Food Wastage Reduction

4.2.1 Economic Structure of Ghana based on FWSAM-C

From the activity columns of the SAM, Ghana's total GDP at factor cost was estimated at GHS107, 428.96 billion in 2005 which is about GHS 2000 billion higher than the original SAM due to the introduction of cooking labor income. The Agriculture sector contributed the largest share of GDP at 41 percent, followed by the services sector (29.61%), household cooking sector (17.23%), the energy sector (5.13%) and the transport sector (6.99%). It is noteworthy that although cassava is a subsector of agriculture, it significantly contributes about 3% of the GDP. Also it is observed that in 2005, the cassava sector was the most labor (46%) and land intensive (2%) sector conforming to the documentary analysis discovery that the crop is widely produced in the country and thus is a major source of employment in the Ghanaian economy. Nevertheless, it contributes only 3% of the labor

[34] Same price was attributed to wastage at the illegal dumping and reuse stages. However, at the illegal dumping stage the price was negated.

[35] The value of waste at the collection stage was valued at the economic cost of food wastage for zero waste estimated by (FAO, 2014)

[36] we included the price required to make composting (for recycle) and anaerobic digestion (recovery) economically feasible in Ghana adapted from (Galgani, Vander Voet, & Korevaar, 2014)

[37] We included the average price required to make engineered landfills and incineration feasible adapted from (Analgate & Rahmaputro, 2014))

[38] Estimated as total value of cassava production in SAM divided by the total production in 2005

[39] Added the net benefit of processing cassava into gari adapted from (Wilhemina, Gayin, & Plahar, 2009)

[40] Added the net benefit of processing cassava into agbelima adapted from (Wilhemina, Gayin, & Plahar, 2009)

income showing the low income levels in the sector and the associated poverty experienced in the sector.

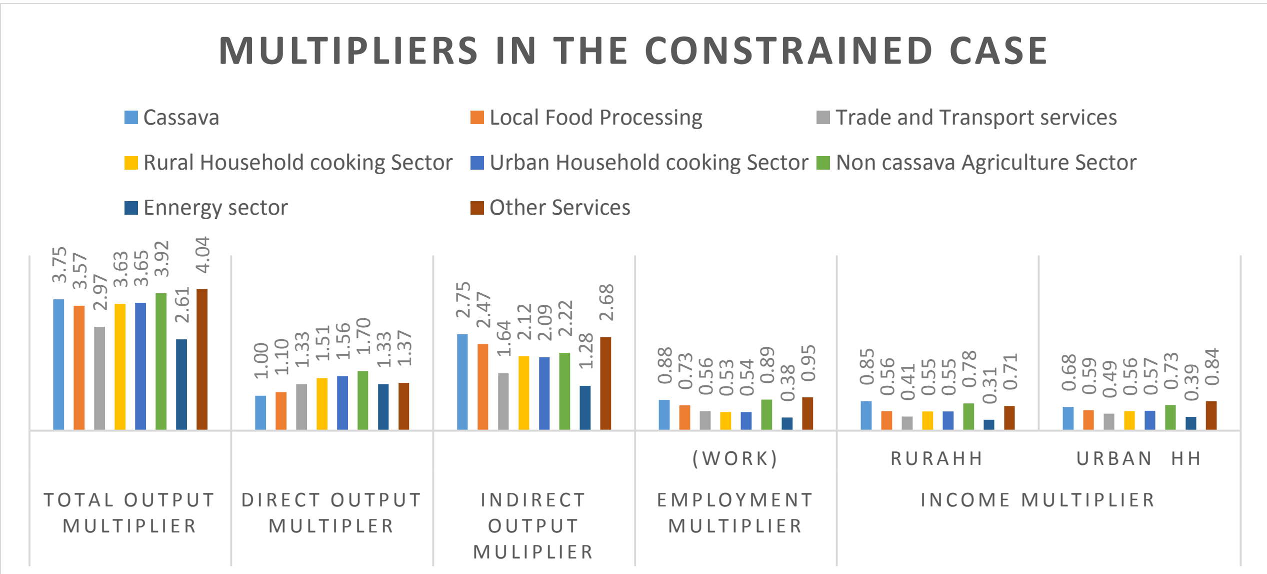
From the Balance of trade analysis, it is observed that Ghana on overall import dependent despite its significant exports in the agriculture sector (about -49737.65 billion GHS). This because most of its exports are in their raw states and thus lose out on the profits of value adding. Thus, from the SAM it is observed that most of the imported products are from the energy sector which include formal food processed products and energy. This is a strong indication of low level of food processing and poor domestic energy supply in the country and the country's overdependence on raw food production which is mostly coupled with lower prices and may be result of the agriculture poverty and high post-harvest loss associate with the country. Nonetheless the SAM shows that cassava is one of the few goods that Ghana is not only non- import dependent but yields exports of 24.82 billion Ghana cedis. Thus, the share of cassava domestic supply is 100%. This highlights the importance of the sector as the number one food security haven.

4.2.2 Analysis of SAM Multiplier effects

4.2.2.1 Overview of multipliers

From the figure below bases on the SAM, when supply of the cassava sector is constrained, a unit increase in exogenous demand in the cassava sector directly increases cassava output, employment and income by a multiple of 1, 1.13. 0.85 And 0.68 billion GHS respectively. Also, for a unit increase in exogenous demand for the cassava sector, the other services sector leads in the total multiplier effects by 4.04 billion GHS while the non-cassava agriculture sector leads in the employment multiplier effect by 0.89 billion GHS.

Figure 4 Adjusted SAM multiplier



4.2.3 Results from the Economic Impact of Policy Shocks

Figure 5 Bar Graph Illustrating the Economic Impact of the Cassava Export Policy

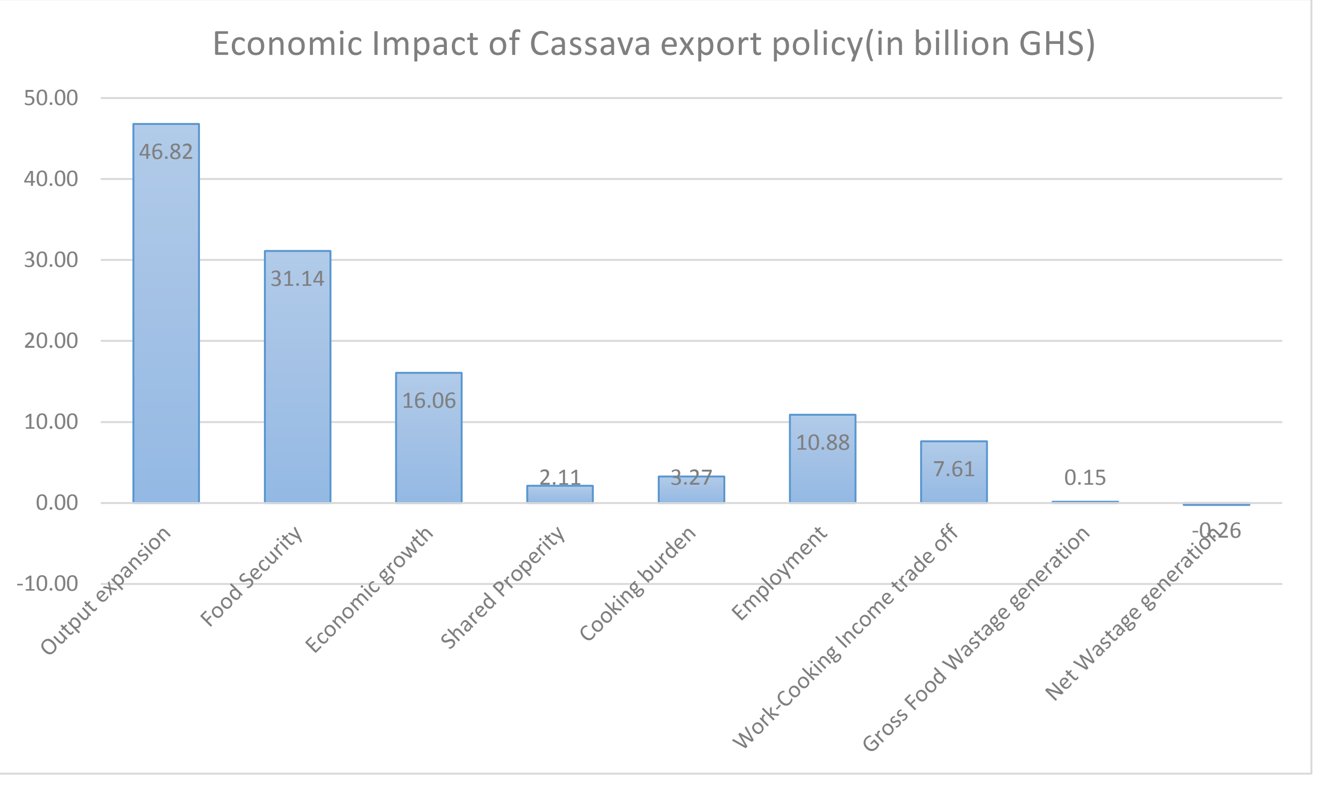
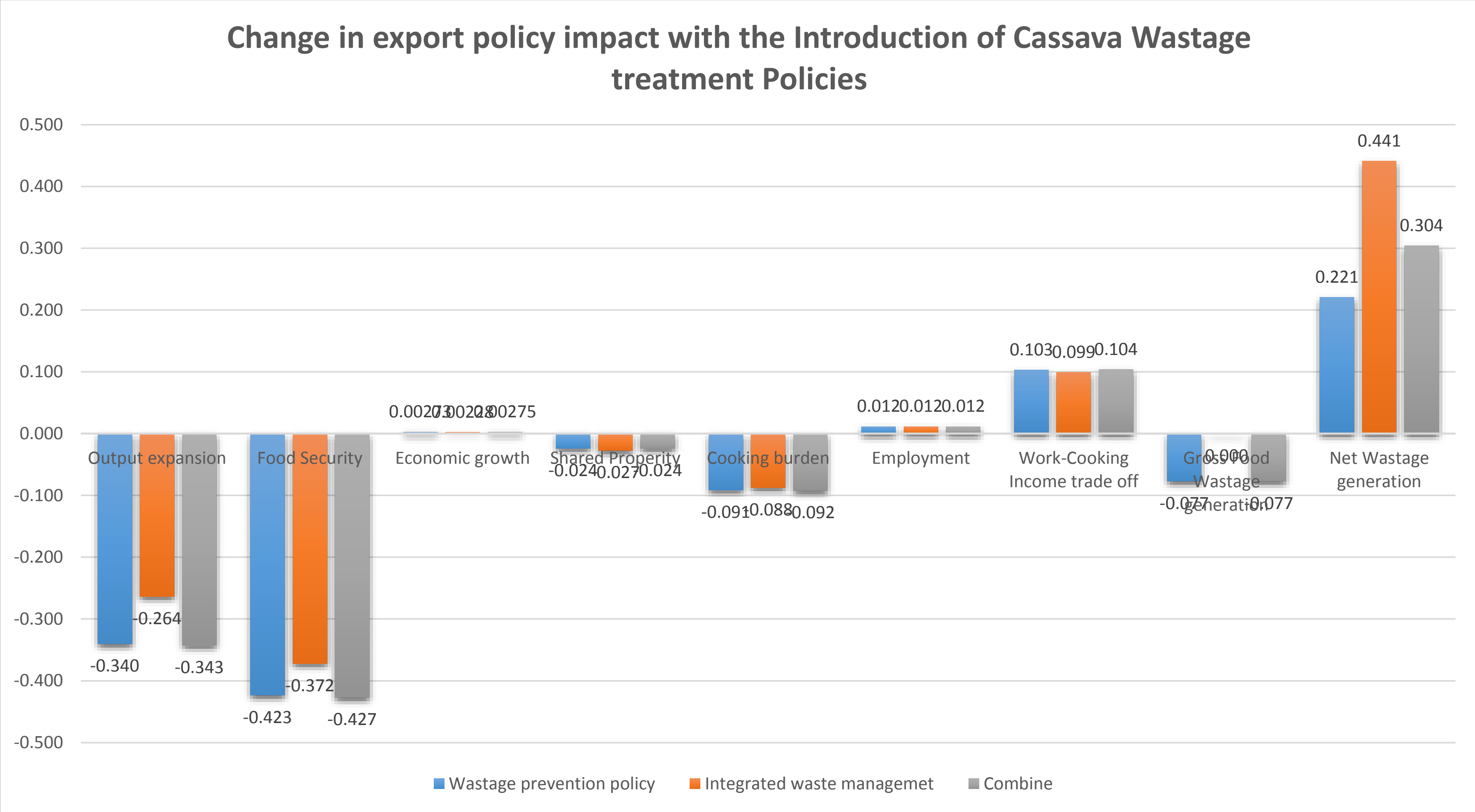


Figure 6 Change in economic impact with the Introduction of Cassava Wastage Treatment Policies



4.2.4 Discussion: Economic Impact of Policy Shocks

4.2.4.1 Output Expansion

As illustrated in the figure 5, we observed that the application of the only the export policy leads to an expansion in the total output of the economy valued at 46.98 billion GHS when the cassava sector is supply inelastic. Nonetheless, the introduction of the waste prevention policy and the integrated waste management policy into the cassava export policy do not yield significant changes to the output growth of Ghana. Instead, the economy experienced slightly lower output changes when these additional policies were implemented with the waste prevention leading to the lowest output expansion (see fig 5 below). The outcome with the waste prevention policy was not surprising since model assumes that when food wastage is reduced, the production of the amount that led to the food wastage is never experienced in the economy. Also note that the new products generated as a result of integrated waste management did not expand total production since this is treated separately in the model and is therefore analysed in section 4.2.4.8.

4.2.4.2 Food Security

To assess food security, change in physical food availability, as aforesaid, we assess the change in Regular Total Supply of agriculture, cassava and local food processing sectors. From figure 4 and 5, it is observed that the increment in cassava exports increases the supply of food by about 31 billion GHS which declines with the introduction of cassava treatment policies individually or jointly (30.713 billion GHS for waste prevention policy, 30.709 billion GHS for combine policy, and 30.764 billion GHS for integrated cassava wastage policy). Since for the waste prevention policy the model assumes that the reduced amount of food wasted or lost is never experienced in the economy, the estimated impact may be understated because in the real world food waste when reduced feeds back into the production or processing stage to be re allocated potentially to international markets whereas food loss reduced is never experienced in the 'changed' economy. However, what is alarming is the relatively higher reduction of food supply as a result of the integrated food waste management policy. Thus, although integrated food wastage management yields significant output of new products such as compost, energy, animal feed and so on, it does this at the cost of food availability.

4.2.4.3 Economic Growth

Economic growth was assessed by the change in GDP at factor cost less change in value added by cooking labor. This because changes in cooking labor factor costs are deductions from GDP that may have accumulated via work if otherwise. From figure 4 and 5, we observed that the cassava export policy leads to a positive growth of the economy by 16.06 billion GHS. This increment advances with the introduction of the waste prevention policy by 0.03 billion GHS. The addition made by the waste prevention policy exceeds that of the integrated waste management policy by 0.001 billion GHS. The difference between the economic growth impact using only cassava wastage prevention policy and the combine policy stands at 0.00002 billion GHS. This implies that the cassava wastage reduction slightly enhances the potential of the export policy to improve economic growth in Ghana. This slight effect is significant since cassava constitute just about one-fifth of food, raw and processed, produced in the country. Therefore, we can infer that including other relevant foods with significant wastage in the economic impact analysis will give an expanded view of the potency of the waste prevention policy.

4.2.4.4 Shared Prosperity

In the baseline case it is observed that the cassava export policy leads to a significant increase of rural household income over the increase in urban household income by about 2.11 billion GHS indicating the strong potential of the policy to improve the poverty levels of rural households. We also observed that the gap between rural household income and urban household income further constricts by 0.02 billion GHS and 0.03 billion GHS with the introduction of the wastage prevention policy and the integrated waste management policy respectively, in favour of rural households. A combination of the three policies yielded the same gains as the cassava prevention policy shock. Thus, for rural households to be more included in the economic growth spurred by an increase in cassava export, policymakers should consider including a wastage prevention policy in the cassava sector especially for households since the cassava wastage is predominantly food waste.

4.2.4.5 Work Income Traded Off For Cooking

Britz et al's (2014) conclusion on possible loss of competitiveness on the global level is relevant on the national level in countries like Ghana where trade-offs between cooking time and food cost savings could widen the gender inequality gap or close the poverty gap. For instance, in Ghana females spend almost 3 times more time on unpaid household chores than males irrespective of employment, residence area (rural or urban) or education status (GSS, 2012). On the other hand, food expenditure accounts for two fifths of household expenditure (GSS, 2008). Thus food waste reduction may imply increasing cooking time and reducing the disposable time for work especially for women or reducing food expenditure leaving more disposable income for households. Thus the trade-offs are assessed via the Labwork and labcook accounts.

A sole application of the cassava export policy to the Ghanaian economy led to an increase in time spent in cooking valued at 3.27 billion GHS. This represents a loss of labor supplied for producing goods and services which contribute to GDP. Since as aforementioned, cooking time for women in Ghana far surpassed that of men in Ghana, this increment also represents an increased burden on females in the country to cook than earn money. Interestingly contrary to the suggestions that food wastage reduction may lead to significant loss in work labor, the study found that introducing a waste treatment policy via reduction reduced the cooking labor by approximately 0.091 billion GHS (Britz, Dudu, & Ferrari, 2014). Compared to the integrated waste management policy and the combined policy, the cassava wastage prevention policy reduced the cooking burden further by 0.003 billion GHS and 0.001 billion GHS respectively. This may be possible because household saves more time from purchasing only food needed for consumption than the increased cooking time to save food from wasting.

4.2.4.6 Employment

An exogenous increase in demand for cassava exports leads to an increase in employment by approximately 10.88 billion GHS which is expounded by the cassava wastage treatment policies by 0.012 billion GHS per our analysis. Thus, we observe that in addition to reducing the cooking burden, the cassava wastage treatment policies increases employment gains to household.

4.2.4.7 Gross Wastage Generation (Food Wastage Footprint)

From the figure 6 above, we observed that the increase in cassava exports by 50% led to an increase in Ghana's food wastage footprint by 0.15 billion. Introducing the integrated waste management policy made no variations to this outcome. However, with the introduction of the cassava prevention policy, the increase in gross cassava wastage was halved. This is because the cassava wastage prevention policy is directly applied to address gross wastage generation. Thus if the objective of policymakers is to reduce their food wastage footprint, this analysis indicate that integrated cassava wastage management has no reducing effect on Ghana's food wastage footprint. Thus interventions targeted at reducing food wastage should do just that, encourage prevention.

4.2.4.8 Net Food Wastage Generation

We observed that the introduction of cassava export policy without any waste management consideration yields an economic cost of about 0.26 billion GHS. This indicated that the cassava export policy generates more net waste than new products which further expands the food wastage footprint. Also, when half of food waste is reduced without any considerations for waste management, the country rather incurs a cost of 0.04 billion GHS. Thus, the inclusion of food wastage reduction to the export policy reduces the economic cost of net wastage generated by 0.221 billion GHS. When gross wastage is managed with an integrated approach in addition to the export policy, the economy benefits by 0.18 billion GHS which is 0.22 billion GHS more than with waste prevention policy. When policies are combined, net waste generated by the waste treatment sectors stands at 0.05 billion GHS. The benefits or positive impacts represent an offset of the new products from food wastage management methods over net waste generated.

4.3 Conclusion

The study attempted to create a national accounting framework which included the wastage and wastage treatment stage of food along the cassava value chain. We went further to consider the impact of an export policy, cassava wastage prevention policy, integrated food wastage management and a combine policy. For the research question on who wins or loses with the policies implemented we found that rural households win since the shared prosperity between rural households and urban households narrows with the introduction of cassava wastage treatment policies. Also, whereas pre-retail supply chain agents' output is reduced by the introduction of waste treatment policies into the export policy, we observed that final consumers gained from the reduction of cooking burden, especially with cassava wastage prevention policy. Moreover, households gain additional employment when waste treatment policies are introduced.

Furthermore on the research question on the best policy alternative for the target variables we observe from the above results that for output expansion, the cassava export policy is best on its own. For inclusive economic growth, an inclusion of waste prevention policy to the export policy holds promise since cassava consumption and production forms a major part of household expenditure and income. We also observed that contrary to claims by some experts that cooking costs of food wastage reduction may lead to loss of household income and GDP, we observe that instead the 'cooking' burden is minimized and economic growth increases with the introduction of cassava wastage reduction. In addition we observed that the introduction of the waste prevention policy actually yields employment gains which exceeds employment lost as a result of cooking.

More so, cassava integrated wastage management has the potential to expound the food wastage problem than alleviate it and thus cassava reduction policy is appropriate for a significant reduction in food wastage. In addition we realized that an integrated food wastage management policy has the potential to worsen food security and thus policymakers need to put restrictions on the amount of food that can be sent to waste management sectors to encourage reduction of food waste than food loss instead since that has the potential to improve food security in the country. However, for gains from new products produced by wastage management sectors to exceed net waste generated, integrated cassava management holds promise.

Therefore, we conclude that cassava wastage reduction in an export-driven Ghana is ideal for reduction of food waste footprint while ensuring inclusive economic growth, employment generation and significant rural poverty reduction. However, for food security gains, wastage reduction should be targeted at food waste than food loss in the cassava sector. Also, for a more sustainable production of new products, in terms of ensuring food security, reducing the food wastage and reducing the rural-urban income inequality, the combine policy is better. Furthermore, rural households win in terms of income distribution, households in general win from the employment gains and reduced cooking burden whereas output producers are the potential losers of introducing cassava wastage treatment policies in a cassava export driven Ghanaian economy.

Chapter 5: Limitations and Recommendation

This chapter explains the possible limitations of the study and makes recommendations for further study. Consequently, we acknowledged that the Social Accounting Matrix analysis is a useful tool for capturing the links between different sectors of the Ghanaian economy which gives an internally balanced representation of the backward and forward linkages between the sectors of the economy. In fact, it gave a better overview of the economy than most one-to-one impact studies on food wastage reduction impact. However, the currently available one was an over a decade old which when compared with the current data in FAOSTAT (see appendix I) we noticed some substantial changes in some sectors of the economy. This limitation is highly relevant, given the static nature of the Social accounting matrix due to its assumptions of Leontief technologies and fixed input and output prices making it only reasonable to use for short run policy analysis.

Also, considering the proven relevance of price volatility and the uncertain demand for waste management products to the cassava sector it would have been more interesting to consider the price effects of policy shocks and the elasticity of demand and supply in the wastage treatment sector which is not possible in the SAM. However, since these results do not consider the price effects, the environmental net benefits and social net benefits of food wastage reduction, a more thorough analysis will give more 'close to reality' results. More so, the model assumes that food wastage will be reduced via technological change but does not explain how the technology will be developed and which particular technology or behavioural change will translate into the results gleaned.

Furthermore, although employment impacts attempt to consider the job distribution between rural and urban households, the analysis does not consider whether they will be desirable for the populace or immigrants, the nature of the job (full time or part time) and whether the job created will be long term or short term. However, using knowledge of the characteristics of the national labor force, composition, nature and labor turnover rate of employment in the country and time series analysis, a further analysis can be made. Again on employment impacts, the results do not indicate if the current residents will qualify for the jobs created. For a more detailed study on the labor impacts, further analysis is proposed.

Furthermore, since the model is static, it is unable to consider dynamic-related changes such as population growth which could increase pressure on local public services as a result of increased economic activity but considers level changes in government expenditure which could be irrelevant if the economic structure of Ghana has changed significantly. Nonetheless, this study argues that since the study was aiming at closely assessing how Ghana's interest in expanding cassava sector into international markets can be impeded or accelerated by food wastage treatment with the most comprehensive data available, the analysis procedure is appropriate. However, recent studies have assessed that there is disparity between Ghana's intended economic focus, export-led growth, and actual focus, finance-led growth (Olaniyi, 2013). Thus, it will be empirical beneficial to assess a case when Ghana's economy is exogenously finance-led to assess the real current economic situation.

Hence, we deduce that the Ghanaian economic structure is strongly driven by government interventions to boost cassava wastage reduction than the sole implementation of export policies since this has the best economic benefit potential per our analysis. It is noteworthy that impacts of the integrated food waste management should be taken with a grain of salt since the economic feasibility of some of these waste management methods, for instance composting, is dependent on the support of external subsidy. Hence, a sensitivity analysis on different years and datasets could provide a clearer analysis of effects.

References

Affogon, H., Mutungi, C., Sanginga, P., & Borgemeister, C. (2015). Unpacking Postharvest Losses in Sub-Saharan Africa: A Meta- Ananlysis. *World Development, 66*, 48-68.

Analgate, S., & Rahmaputro, S. R. (2014). *Comparison between Landfill gas and waste Incineration for power generation in Accra, Ghana.*

Apthorpe, R. (1977). A Comment on Andrew Peare's Review of Global-2. In *Development and Change* (p. 8).

Baabereyir, A. (2009). *Urban Environmental Problems In Ghana: A Case Study of Social and Environmental Injustice in Solid Waste Management In Accra And Sekondi-Takoradi.* PhD Thesis , University of Nottingham., School of Geography, Nottingham.

Baabereyir, A. (2009). *Urban Environmental Problems In Ghana: A case Study of Social and Environmental Problems in Ghana.* PhD Thesis, University of Nottingham, School of Geography.

Breisinger, C., Marcelle, T., & Thurlow, J. (2010). *Social Accounting Matrices and Multiplier Analysis.* Updated version, International Food Policy Research Institute, Washington DC.

Britz, W., Dudu, H., & Ferrari, E. (2014). Economy-wide Impacts of Food Waste Reduction: A General Equilibrium Approach. *EAAE 2014 Congress 'Agri-Food and Rural Innovations for Healthier Societies' .* Ljubljana, Sloveni.

CGIAR. (2015, February 13). *News: Research Programme on Roots, tubers and bananas*. Retrieved from http://www.rtb.cgiar.org: http://www.rtb.cgiar.org/tag/cassava/

Coulibaly, O., Arinloye, A. D., Faye, M., & Abdoulaye, T. (2014). *REGIONAL CASSAVA VALUE CHAINS ANALYSIS IN WEST AFRICA.*

Cuellar, A. D., & Webber, M. E. (2010). Wasted Food, Wasted Energy: The Embedded Energy in Food Waste in the United States. *Environmental Science & Technology, 44*(16), 6464-6469.

Durkin, A. (2015). *Grow Markets, Fight Hunger: A Food Security Framework for US-Africa Trade Relations.* The Chicago Council of Global Affairs, Global Agriculture.

FAO. (1981). Food loss Prevention in Perishable in Perishable Crops. *Food and FAO Agriculture Service Bulletin, 43*.

FAO. (2011). Global food losses and food waste – Extent, causes and prevention. *Interpack 2012, Dusseldorf, Germany.* Rome: Food and Agriculture Organisation of United Nations(FAO); Swedish Institute for Food and Biotechnology (SIK).

FAO. (2013). *Global Food losses and Food waste.* World Bank.

FAO. (2014). *Food Wastge Footprint.* Final Report, Food and Agricultural Organisation of the United Nations, Climate, Energy and Tenure Division. Retrieved from http://www.fao.org/3/a-i4030e.pdf

FAO, IFAD and WFP. (2014). *The State of Food Insecurity in the World.* FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome. Retrieved from E-ISBN 978-92-5-108543-1

FAO, IFAD AND WFP. (2014). *The State of food insecurity in the world 2014.* Infromation, FAO, Rome.

FAOSTAT. (2005-2011). Cassava production.

FAOSTAT. (2005-2011). Cassava Production. Retrieved from http://faostat3.fao.org/browse/Q/*/E

Foster, G. M. (1965). Peasant Societies and the Image of Limited Good. *American Anthropologist, 62*, pp. 293-315.

Galgani, P., Vander Voet, E., & Korevaar, G. (2014). Compost, Anaerobic digestion and Biochar Production in Ghana in Northern Ghana. *Waste Managment, 34*(12). doi:10.1016/j.wasman.2014.07.027

Global Knowledge Initiative. (2014). *Reducing Global Food Waste and Spoilage.*

GSS & IFPRI. (2007). *A 2005 Social Accounting Matrix(SAM) for Ghana.* Ghana Statistical Service and International Food Policy Research Institute.

GSS. (2008). *Ghana Living Standards Survey Report of the Fifth ROund.* Ghana Statitstical Service.

GSS. (2012). *Ghana TIme-Use Survey 2009.* Ghana Statistical Survey.

Haq, Z. U. (2012). *Food Value chain analysis: A review of selected studies for Pakistan and Guidelines for Further Research.* Working Paper No. 010, International Food Policy Research Institute, Pakistan Strategy Support Program.

Harriss, J. (1992). *Rural Development: Theories of Peasant Economy and Agrarian Change.* London and New York: Routledge.

Hertwich, E. G. (2011). The Life Cycle Environmental Impacts Of Consumption. . *Economic Systems Research, 23*(1), 27-47.

Hodges, R., Buzby, J., & Bennet, B. (2011). Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. *Journal of Agricultural Science*(149), 37 –45.

IFAD & FAO. (2005). *A review of cassava in Africa with country case studies on Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin. VALIDATION FORUM ON THE GLOBAL CASSAVA DEVELOPMENT STRATEGY.* International Fund for Agriculture Development & Food and Agriculture Organisation of the United Nations, Rome.

Irfanoglu, Z. B., Baldos, U., Hertel, T., & van der Mensbrugghe, D. (2014). Impacts of Reducing Global Food Loss and Waste on Food Security, Trade, GHG Emissions and Land Use. . *17th Annual Conference on Global Economic Analysis, GTAP.* Dakar, Senegal.

Kaminski, J., & Christiaensen, L. (2014). *Post-Harvest Loss in Sub-Saharan Africa: What Do Farmers Say?* Policy Research Working Paper , The World Bank , Africa Region, Office of the Chief Economist .

Kleih, U., Phillips, D., Wordey, T. M., & Gregory, K. (2013). *Cassava Market and Value Chain Analysis: The Ghana case study.* Final Report, Food Research Institute(Accra, Ghana) & Natural Resources Institute University of Greenwich (UK). Retrieved from http://cava.nri.org/documents/publications/GhanaCassavaMarketStudy-FinalFebruary2013_anonymised-version.pdf

Kwasek, M. (2012). Threats to food security and common agricultural policy. *economics of agricultural, 4*.

Kwasek, M. (2012). Threats to food security and Common Agricultural Policy. . *Economics of Agriculture.*

lipinski, b., hanson, c., lomax, j., kitinoja, l., waite, r., & searchinger, t. (2013). *Installment 2 of Creating a sustainable food future: Reducing food loss and waste.* Retrieved from World resource institute: http://www.worldresourcesreport.org.

lipinski, b., hanson, c., lomax, j., kitinoja, l., waite, r., & searchinger, t. (2013). *Reducing food loss and waste.* Working paper, World Resource Institute. Retrieved from World resource institute: http://www.worldresourcesreport.org.

MOFA. (2012). *Report on 2011-2012 Pilot Ghana Agricultural Production Survey(GAPS).* Ministry of Food and Agriculture, Statistics Research and Information Directorate(SRID).

Naziri, D., Quaye, W., Siwoku, B., Wanlapatit, S., Phu, T. V., & Bennett, B. (2014). The diversity of postharvest losses in cassava value chains in selected developing countries. *Journal of Agriculture and Rural Development in the Tropics and Subtropics, 115* (2), 111–123. Retrieved from www.jarts.info

Olaniyi, E. (2013, December). Testing Finance-Led, Export-Led and Import-Led Growth Hypotheses on Four Sub-Saharan African Economies. *Munich Personal RePEc Archive (MPRA)*(52460). Retrieved from http://mpra.ub.uni-muenchen.de/52460/

Papargyropoulou, E., Lozano, R., S. J., & Wright, N. (2014). The food waste hierarchy as a framewrrk for the management of food surplus and food waste. *Journal of cleaner production*.

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. *Phil. Trans. R. Soc., 365*, 3065-3081.

Parfitt, J., Barthel, M., & MacNaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society Biological Science*(365), 3065–308.

Ratinger, T. (2013). Food loses in the selected food supply chain. *140th European Association of Agricultural Economists Seminar.* Italy.

Reynolds, C. (2013). *Quantification of Austrlian Food Wastage with Input-Output Analysis.* PHD thesis, University of South Australia, Centre for Industrial and Applied Mathematics, School of Information and Mathematical Sciences, Australia.

Ricker-Gilbert, J., Jayne, T., & Shively, G. (2013, February 12). Addressing the 'Wicked Problem' of Input Subsidy Programs in Africa. *Applied Economic Perspectives and Policy, 35*(2), 322-340. doi:doi:10.1093/aepp/ppt001

Robinson, E., Kolavalli, S., & Diao, X. (2012). Food Processing and Agricultural Productivity Challenges: The Case of Tomatoes in Ghana. *Transforming Agriculture Conference.* IFPRI.

Searchinger, T., C., H., Ranganathan, J., Lipinski, B., Waite, R., Winterbottom, R., . . . Heimlich, R. (2013). *Installment 1: Creating a sustainable food future.* Working paper, World Resource Institute. Retrieved from http://www.worldresourcesreport.org.

Searchinger, T., Hanson, C., Ranganathan, J., Lipinski, B., Waite, R., Winterbottom, R., . . . Heimlich, R. (2013). *The Great Balancing Act .* Working Paper, World Resource Institute.

Smil, V. (2004). Improving efficiency and reducing waste in our food system. *Environmental Science, 1*(1), 17-26.

Stuart, N. (2009). *Waste: Uncovering the Global Food Scandal.* London: Penguin.

Taussig, M. (2006). Peasant Economics and the Development of Capitalist Agriculture in the Cauca Valley, Columbia. In J. Harriss, *Rural Development: Theories of Peasant Economy and Agrarian Change* (pp. 178-205). London and New York: Routledge.

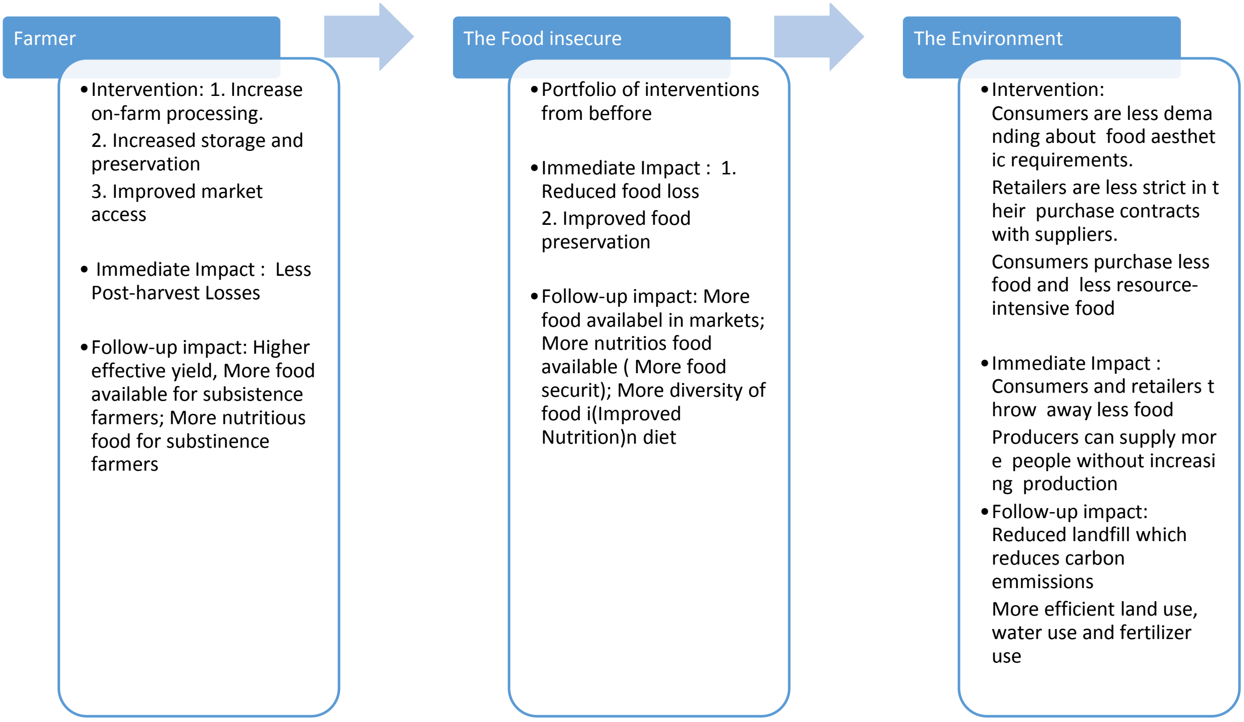
The Rockefeller Foundation. (2013). *Food Waste and Spoilage Initiative Strategy Template.* Decision Intelligence Document, The Rockefeller Foundation, Nairobi, Kenya.

Wilhemina, Q., Gayin, J., & Plahar, W. A. (2009). Economic Comparison of Cassava Processing Methods in Some Selected Districts of Ghana, Africa. *Journal of Root Crops, 35*(2), 211-218. Retrieved from http://www.researchgate.net/publication/228275955

APPENDIX A

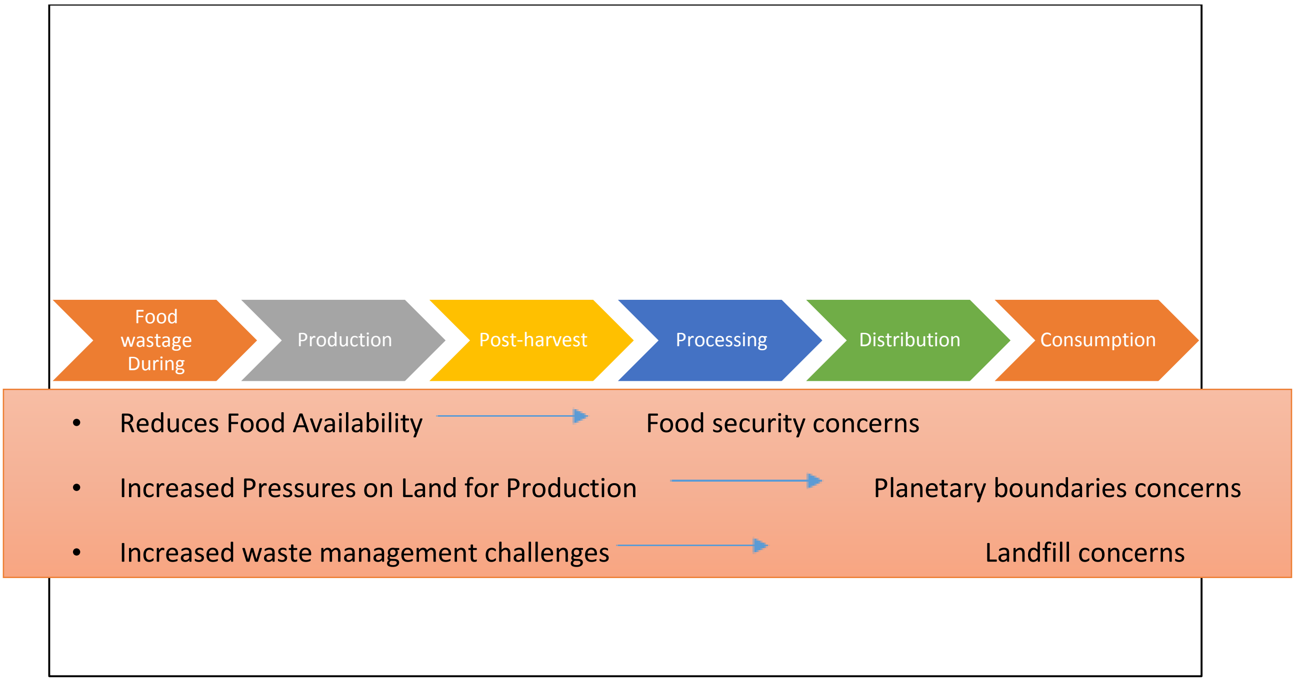
PART 1: INTRODUCTION

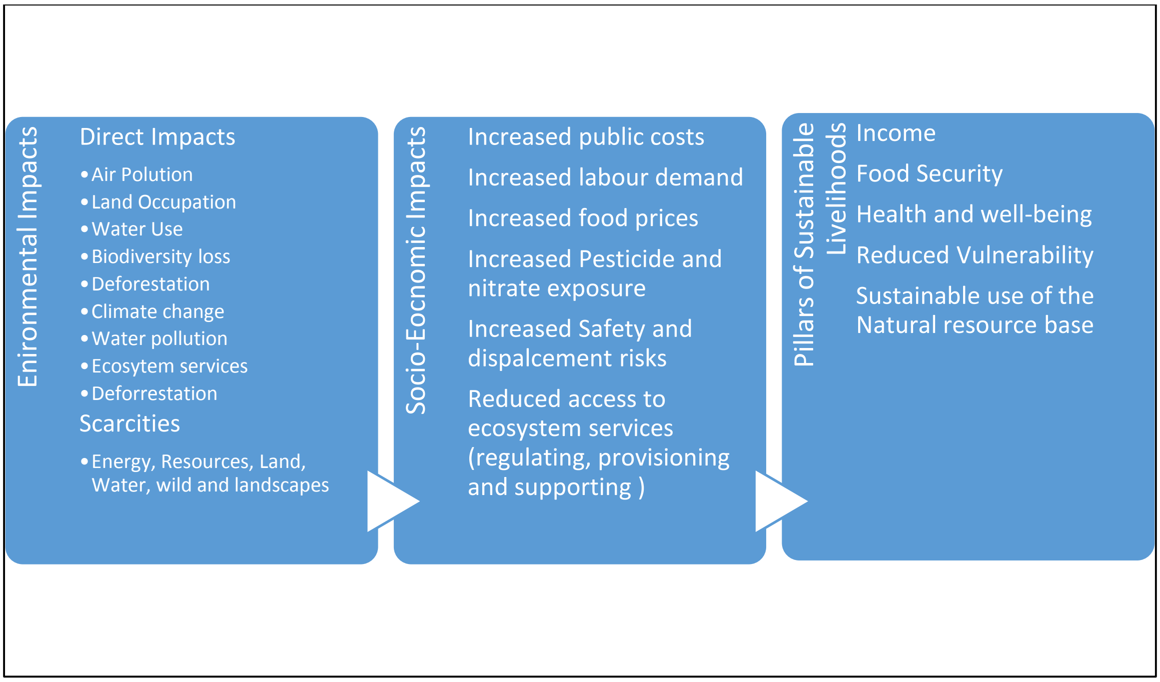
Figure 7 Quantity effects of Food Wastage reduction



Source: Adapted from (The Rockefeller Foundation, 2013); (FAO, 2013)

Figure 8 Full impact of food wastage





Source: Adapted from (FAO, 2014)

PART 2: The Concept of Food Wastage

Figure 9 Components of food wastage

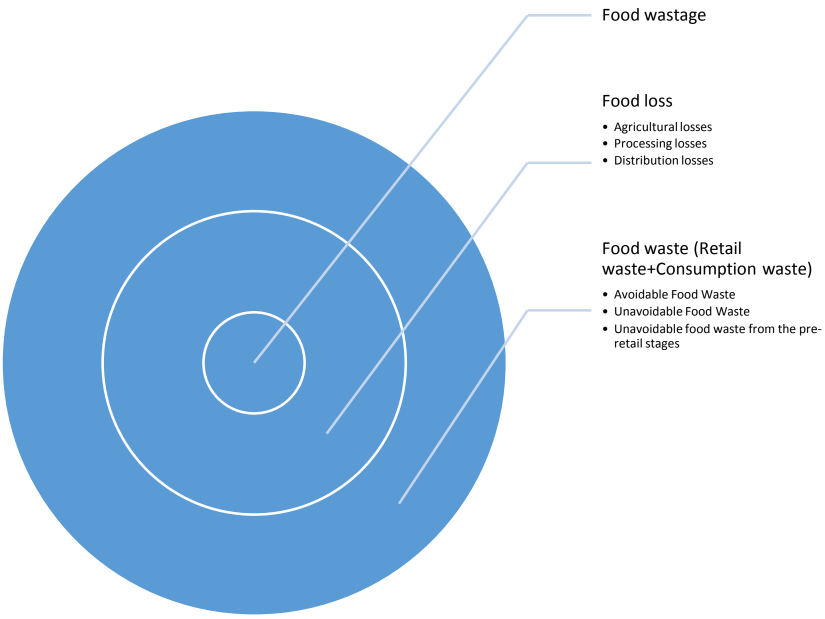
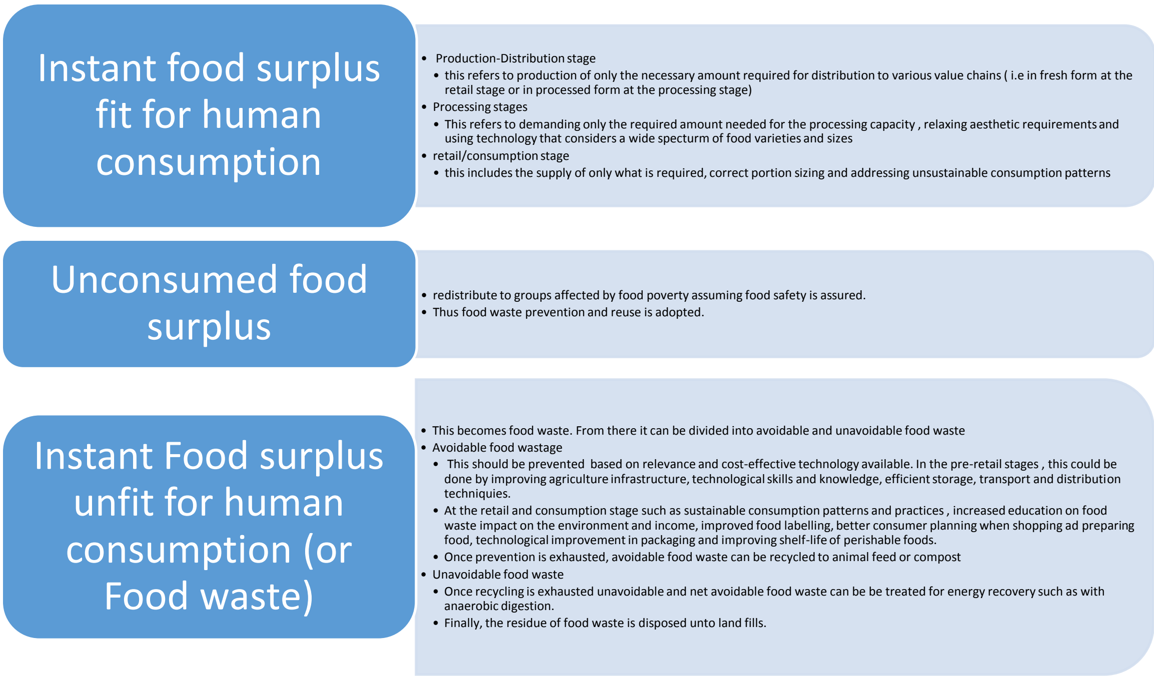


Figure 10 Including Nutrition Perspectives in Food Wastage Definition



PART 3: Treatment of Food wastage vs Waste

Figure 11 Waste hierarchy adapted from European Parliament Council, 2008

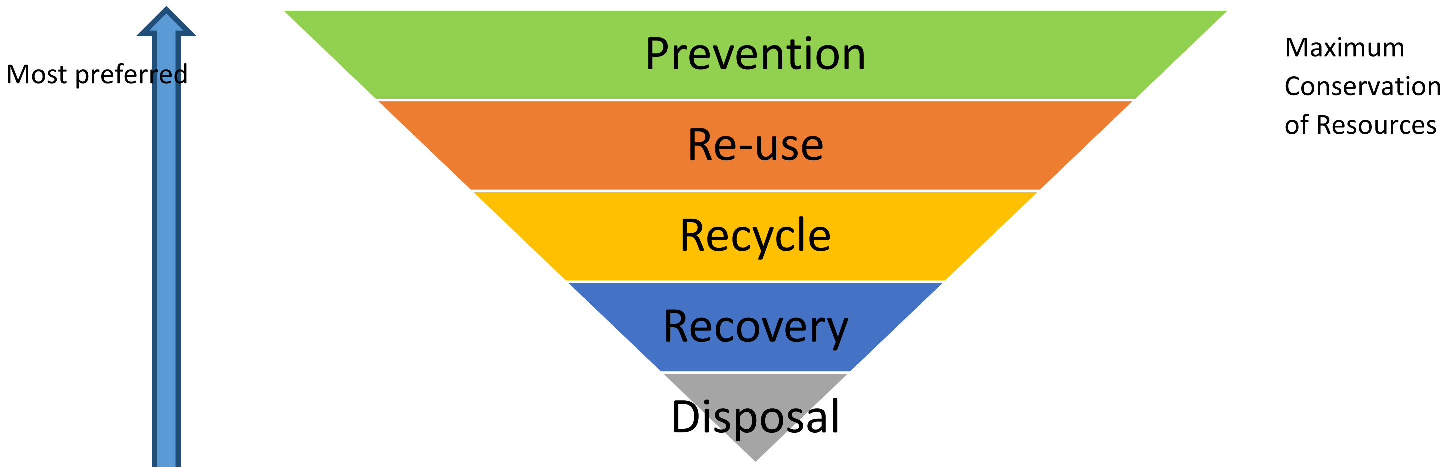
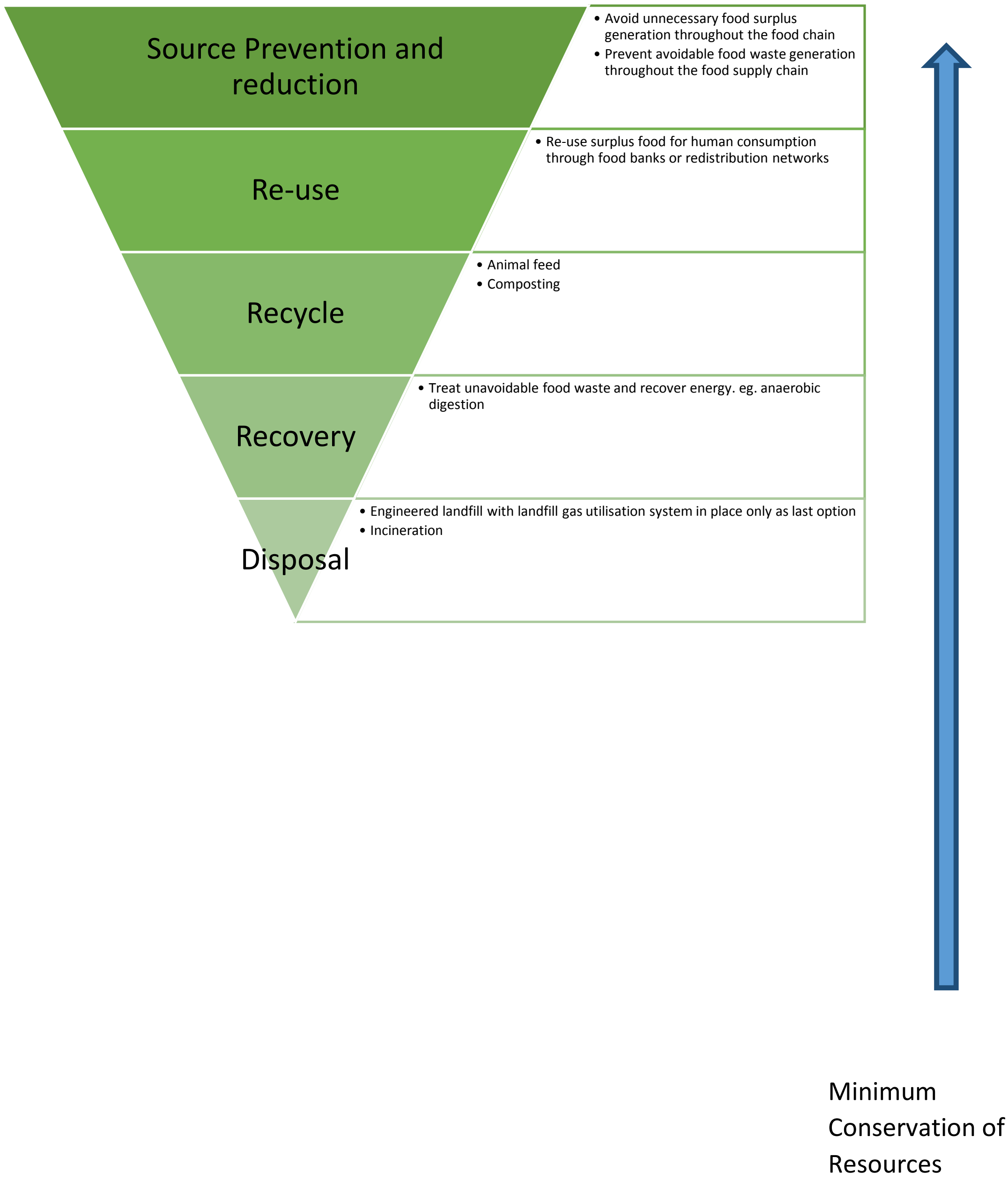


Figure 12 Food waste hierarchy. Source: Adapted from (Papargyropoulou, Lozano, Steinberger,, & Wright, 2014)


Source Prevention and reduction
Avoid unnecessary food surplus generation throughout the food chain
Prevent avoidable food waste generation throughout the food supply chain
Re-use
Re-use surplus food for human consumption through food banks or redistribution networks
Recycle
Animal feed
Composting
Recovery
Treat unavoidable food waste and recover energy. eg. anaerobic digestion
Disposal
Engineered landfill with landfill gas utilisation system in place only as last option
Incineration
Minimum Conservation of Resources

Part 4: Extensions of the Simple Food System

Figure 13 The Simple Food System. Source: Adapted from (Kleih, Phillips, Wordey, & Gregory, 2013)

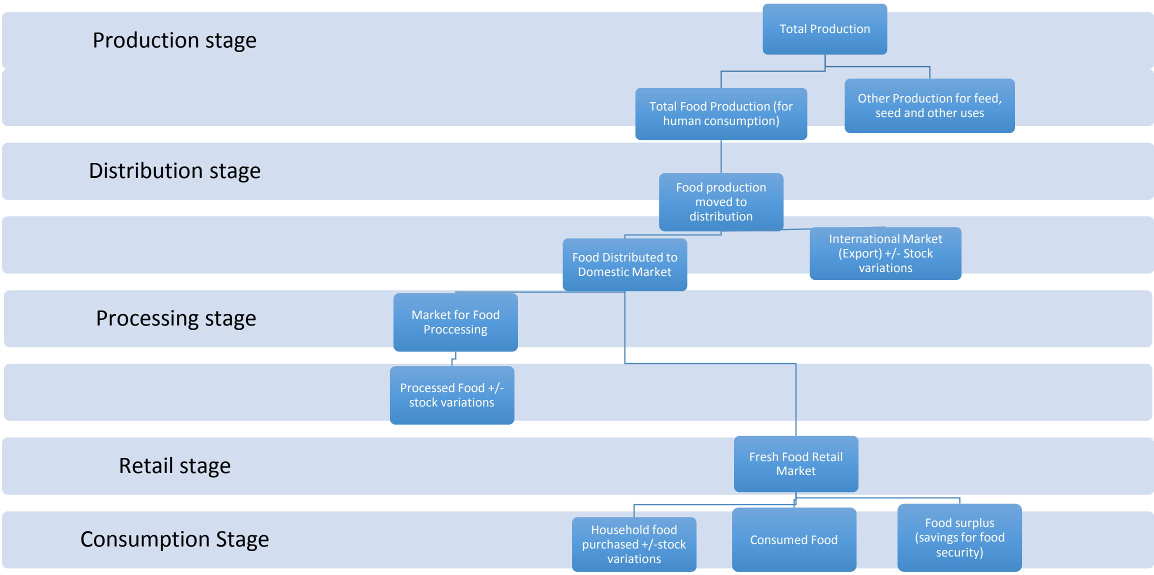


Figure 14 Food Wastage Inclusive Food System Adapted from (Papargyropoulou, Lozano, Steinberger, & Wright, 2014)

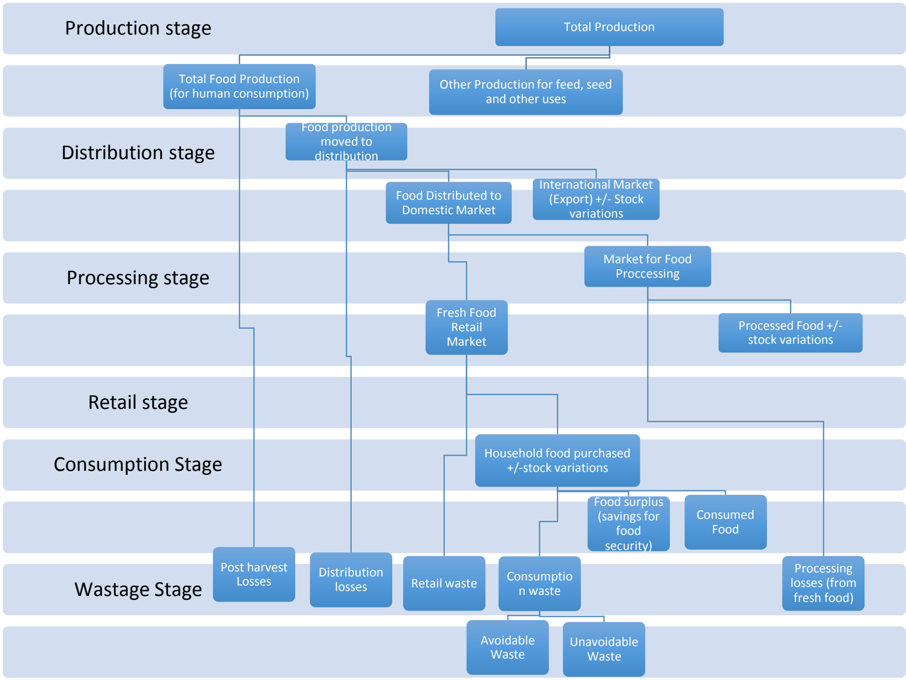
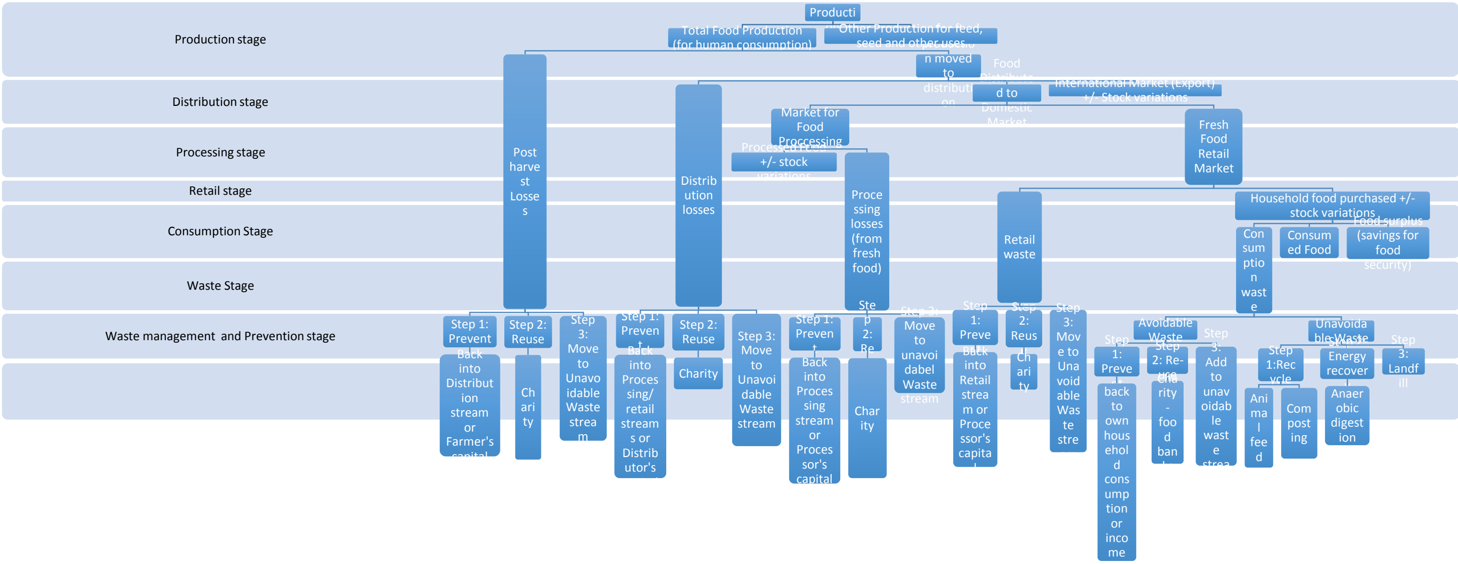


Figure 15 Sustainable Food System. Adapted from (Reynolds, 2013)



APPENDIX B- Methodology

PART 1: Background of study area (Maps of Ghana)

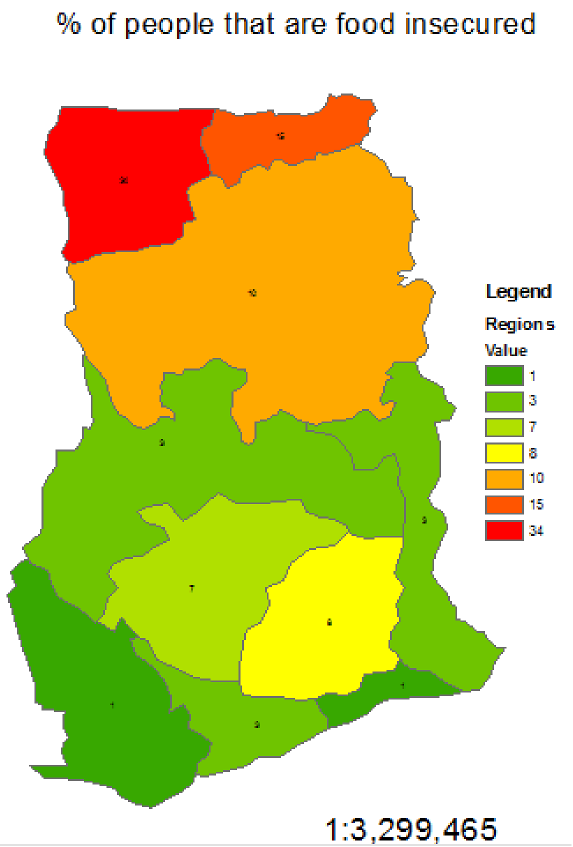


Figure 16 Map of Ghana -food insecurity(Source: WFP, FAO- Ghana)

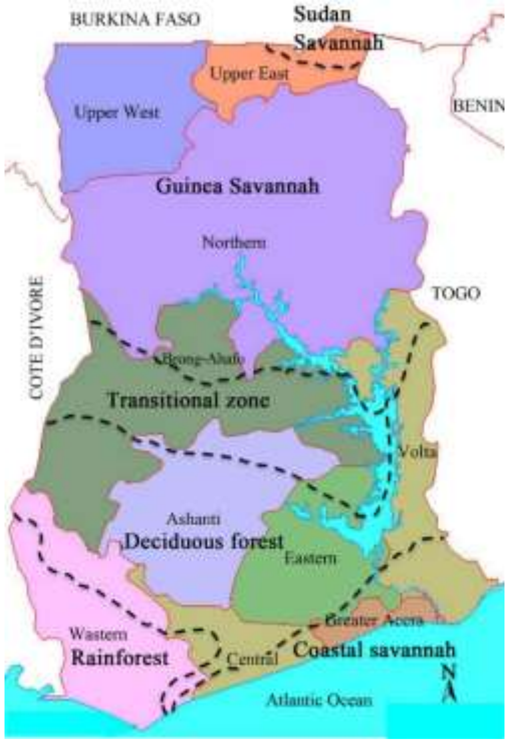


Figure 17 Map of Ghana- Regions and Vegetation Distribution of Ghana

PART 2: POLICIES THAT TARGET FOOD WASTAGE

Table 8 Types of Policies used globally and their target in food security. Source: Siam (2008)

Item	Availability	Accessibility	Sustainability
Support Policy	Producer's support	Consumers support	
Production Policy	Self-sufficiency and self-reliance		
Strategic stocks policy			Sustainable availability
Trade Policy	Relaxing food import constraints		Stocking through imports

** Note that it excludes food wastage policies*

Figure 18 Examples of OECD countries and their food waste policies. Adapted from (OECD, 2014).

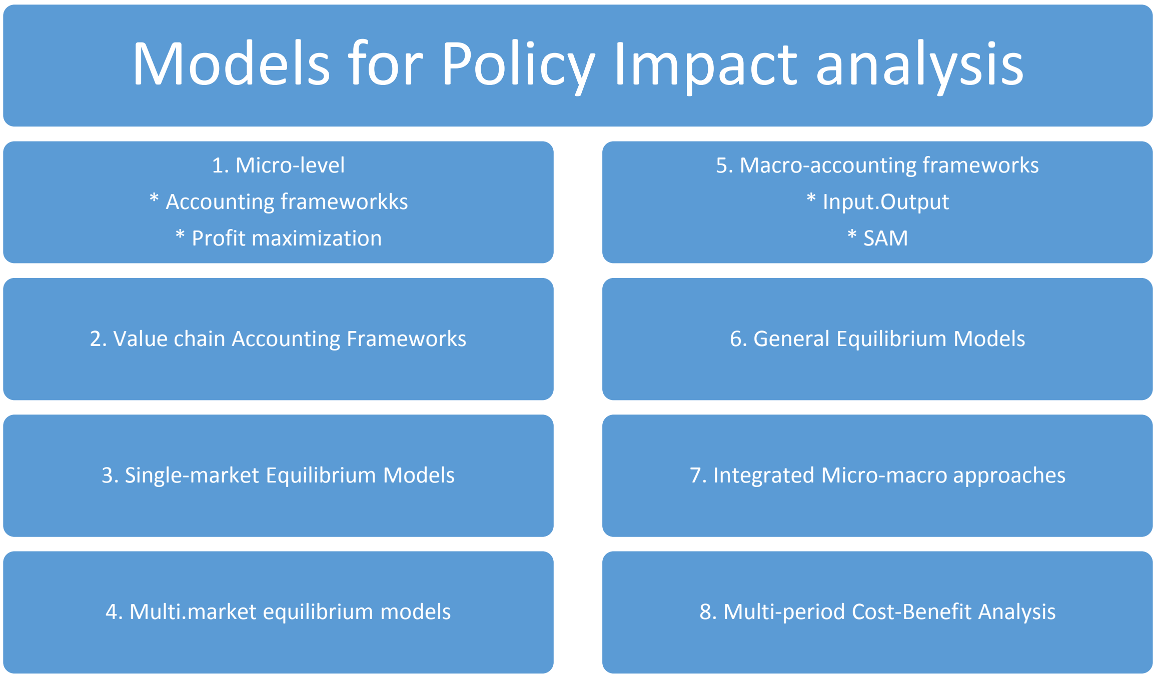
OECD country	Food waste intervention
Australia	National Waste Policy: Less Waste, More Resources
Finland	Waste Act
Germany	Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal
Korea	Wastes Control Act
New Zealand	Waste Minimisation Act
Scotland	Waste Regulations.
Japan	Law for the Promotion of Recycling and Related Activities for the Treatment of Cyclical Food Resources (Food Waste Recycling Law) [41]
Ireland	2009 Waste Management (Food Waste) Regulations[42] Household Food Waste Regulation [43]

[41] Food waste is the central focus of this law since it aims both at preventing and reducing food waste. It also promotes recycling food waste into animal feed and fertilisers as well as energy recovery.

[42] This outline the requirements for the catering sector in relation to management of food waste, including segregation and processing

[43] Promotes the segregation and recovery of household food waste. The regulation directs sources segregated household food waste to composting, and to other forms of treatment, and imposes obligations on waste collectors as well as on households.

Figure 19 Selected models for Quantitative impact analysis. Source: Goettingen University (2009)



Part 3: The Full Food Life SAM

Table 9 Aggregation and Expansion of the Accounts of the Original SAM

Original SAM (FWSAM-A)			Food Wastage Inclusive SAM (FWSAM-B)			Full Food Life SAM (FWSAM-C)
Activities and commodities			Aggregation		Expansion	Expansion
Acass	ccass	Cassava	acass	ccass		
Alocf	clocf	Informal food processing	alocf	clocf		
Atrad	ctrad	Trade services	atrtr	ctrtr		
Atran	ctran	Transport services				
amaiz	cmaiz	Maize	agric	cagric		
Arice	crice	Rice				
Asorg	csorg	Sorghum and millet				
	cogrn	Other cereals				
ayams	cyams	Yams				
acyam	ccyam	Cocoyams				
aplan	cplan	Plantains				
acpea	ccpea	Cowpea				
asbea	csbea	Soyabean				
apoil	cpoil	Palm oil				
agnut	cgnut	Groundnuts				
aonut	conut	Tree nuts				
afrud	cfrud	Fruit (domestic)				
afrue	cfrue	Fruit (export)				
avegd	cvegd	Vegetables (domestic)				
avege	cvege	Vegetables (export)				
acoco	ccoco	Cocoa beans				
aocro	cocro	Other crops				
aoexp	coexp	Export industrial crops				
achik	cchik	Chicken broiler (mostly imported)				
aeggs	ceggs	Eggs and layers (domestic)				
abeef	cbeef	Beef				
agoat	cgoat	Sheep and goat meat				
aoliv	coliv	Other meats				
afish	cfish	Fishing				
afore	cfore	Forestry				
amine	cmine	Mining				
aforf	cforf	Formal food processing				
acopr	ccopr	Cocoa processing				
adair	cdair	Dairy products				
ameat	cmeat	Meat and fish processing				
atext	ctext	Textiles				
aclth	cclth	Clothing				
afoot	cfoot	Leather and footwear				
awood	cwood	Wood products				

apapr	cpapr	Paper products, publishing and printing				
ametl	cmetl	Metal products	energy	cenergy		
acapt	ccapt	Capital goods				
	coils	Crude and other oils				
apetr	cpetr	Petrol				
adies	cdies	Diesel				
afuel	cfuel	Other fuels				
	cfert	Fertilizer				
achem	cchem	Other Chemicals				
awatr	cwatr	Water				
aelec	celec	Electricity				
aosrv	cosrv	Other services	aosrv	cosrv		
acons	ccons	Construction				
acomm	ccomm	Communication				
abusi	cbusi	Business services				
areal	creal	Real estate				
acsrv	ccsrv	Community services				
aadmn	cadmn	Public administration				
aeduc	ceduc	Education				
aheal	cheal	Health				
Factors						
labself	Self-employed labor		Labwork	cooking labour	labcook	
labunsk	Unskilled labor					
labskll	Skilled labor					
capa	Capital (agriculture)		capital			
capn	Capital (other)					
land	Land		land			
Households						
hrur	Rural households		Household cooking sectors	hcook_rur		
hurb	Urban households			hcook_urb		
Other accounts						
trc	CIF-FOB margin for imported goods		gov			
gov	Government					
dtax	Direct taxes					
stax	Sales taxes					
mtax	Import tariffs					
etax	Export taxes					
s-i	Savings-investment					
row	Rest of world					
food wastage						

waste types			Fresh Cassava Roots	FCR		
			Gari	GAR		
			Agbelima	AGB		
waste collection sector			wcollect			
Waste treatmeent sectors						disposal
						resuse
						recycle
						recovery
						illegal dumping

Table 10 General Framework of the Full Food Life SAM

	Sec	Comm	Factors	wcollect	wtyp	wtreat	Hhold	Inst	Total
Sec		X12		W15	W16				X1
Comm (Incl. cooked food)	Z21			W25			C24	E	Z2
Factors	V31								V3
wcollect	W51	W52							W5
Wtyp	W61					W67			W6
Wtreat					W76				W7
Hhold			V43						Y4
Inst.		F82					S84		E
Total	X1	Z2	V3	W5	W6	W7	Y4	E	

Where:

Sec= Regular sectors (Including household cooking sector for urban and rural households)

Comm= Regular commodities (Including cooked food)

Factors = labour for cooking, labour for working, capital and land

Wcollect= Waste collection sector

Wtyp= food value chains (we used the gari, agbelima and fresh cassava food chains)

Wtreat= Waste treatment methods(We chose illegal dumping, e-disposal referring to engineered landfills and gas generating incinerators, recovery which refers to anaerobic digestion, reuse which refers to food banks and recycle which refers to composting)

Hhold= Household (urban and rural)

Inst. = institutions (government, rest of the world and savings-investment)

Z21 = intermediate demand of comm by sec (this represents part of total intermediate demand that is used in the production of commodities)

V31= Value added demanded by sec for production of comm

W51= waste collection services demanded by Sec

W61= Intermediate demand of food wastage from wtyp by sec (this represents part of total intermediate demand that is lost or wasted)

X12= Domestic supply of comm to sec

W52= domestic supply of comm to Wcollect

F82= imports, taxes and tariffs on comm paid to Inst.

V43= factor payments to household =sum gives the GDP at factor cost

V3= factor expenditures

W15= waste collection service payments to Wcollect by sec

W25= Food loss and food waste supplied by fresh cassava roots and cooked food to Wcollect

W16 = Food wastage supplied by sec

W76= Net waste and New products supplied by Wtreat

W67= Net waste and New products intermediately demanded by Wtreat

C24= final demand of comm by households (does not include food wastage)

S84= part of household income saved or transferred to other institution accounts

E= Final demand by Inst

Part 4: The Fixed Price Food Wastage Model

Table 11 Changes in the Assumptions of the traditional multiplier model

Traditional model:	The food wastage multiplier model
Expenditure=income in endogenous accounts; total income.	To maintain this assumption in the waste treatment and wastage sectors we allowed multiple waste types to be treated by multiple treatment methods using an allocation matrix (Reynolds, 2013)
Total expenditure and total income in endogenous accounts are endogenous variables	
Technical coefficients for sectors are fixed. i.e. average expenditures=marginal expenditures	Technical coefficients for regular sectors are fixed but technical coefficients for the food wastage sector is alterable in the wastage prevention vector

Linear relationship between endogenous variables and exogenous variables (based on the hypothesis that there is lack of substitution between different inputs and factors for all productive sectors and between different final goods for all institutions). No substitution between inputs and final output.	To maintain this at the wastage stages, we created the wastage account where all waste produced by the regular sectors moves to the waste treatment sectors to produce net waste and new products. Base d on this, what is produced as final output cannot be used as input and input cannot be used as final output.
No constraints in the supply capacity of the commodities account (surplus or unlimited productive capacity).	In the constrained case we relax this assumption.
Assume that prices used to express values in the SAM do not change because of the changes in exogenous demand (fixed prices)	

Technical coefficients matrix

This explains the economic structure of an economy when supply of sectors is unconstrained while assuming institution account to be exogenous

Table 12 Matrix of technical coefficients (M)

	Endogenous Accounts							Exogenous Accounts
	Sec	Comm	Factors	wcollect	wtyp	wtreat	Hhold	Inst
sec		b=X12/Z		g3=(W15/W5) *(1-gr)	g1=(W16/W6) *(1-gr)			
comm	a=Z21/X1			g2=(W25/W5) *(1-gr)			c=C24/Y4	F28
Factors	v=V31/X!							
Hhold			1					
wcollect	g4=(W51/X1)*(1-gr)	g5=(W52/Z2) *(1-gr)						
wtyp	g6=(W61/X1) *(1-gr)					S67*(1-gr)		
wtreat					g7=(W76/W6) *(1-gr)			
Inst.		L=F82/Z2					s=S84/Y4	
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	E8

Where,

a is input coefficients (i.e., input or intermediate shares in production)

v is the share of value-added or factor expenditure in gross output gr is the Food wastage prevention vector (the percentage of food wastage prevented)

g4 is the share of waste collection services expenditure of total production

g6 is the gross food wastage share of total production

b is the share of domestic supply in total supply

g5 is the share of waste collection services of total supply

L is import rate or commodity tax rate (the share of imports or commodity taxes in total supply)

g3 is the waste collection rate (waste collection services share of total wastage production)

g2 is the food wastage rate (food wastage share of total wastage production)

g1 is food wastage share of total food wastage supply

g7 is the new products and net waste share of total food wastage supply

S67 is the waste treatment allocation matrix= share of food wastage allocated to waste treatment method

c is household consumption expenditure shares

s is the household savings rate (i.e., savings as a share of total household income)

Adjusted Technical coefficients matrix

This explains the economic structure of an economy when supply of a sector is constrained assuming Institution Account is exogenous

Table 13 Matrix of Adjusted technical Coefficients (M)*

	Endogenous Accounts							Exogenous Accounts
	Sec	Comm	Factors	wcollect	wtyp	wtreat	Hhold	Inst
sec		If (D=1, 0,b)		g3	g1			
comm	A			g2			c	F28
Factors	V							
Hhold			1					
wcollect	g4	If (D=1, 0,g5)						
wtyp	g6					S67		
wtreat					g7			
Inst.		If (D=1, 0,L)					s	
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	E8

Table 14 Constrained supply sector vector

	Comm
Sec	D

This extended setup allows us to choose supply constrained sectors

If D= 1: sector is supply constrained

If D=0: sector is not supply constrained

Identity Matrix

Table 15 Identity matrix (I)

	Endogenous Accounts							Exogenous Accounts
	Sec	Comm	Factors	wcollect	wtyp	wtreat	Hhold	Inst
sec	1	I12=0	0	0	0	0	0	0
comm	0	I22=1	0	0	0	0	0	0
Factors	0	I32=0	1	0	0	0	0	0
Hhold	0	I42=0	0	1	0	0	0	0
wcollect	0	I52=0	0	0	1	0	0	0
wtyp	0	I62=0	0	0	0	1	0	0
wtreat	0	I72=0	0	0	0	0	1	0
Inst.	0	I82=0	0	0	0	0	0	1

B Matrix

Table 16 B Matrix

	Endogenous Accounts							Exogenous Accounts
	Sec	Comm	Factors	wcollect	wtyp	wtreat	Hhold	Inst
sec	0	If (D= 1, b, I12)	0	0	0	0	0	0
comm	0	If (D=1, 0,I22)	0	0	0	0	0	0
Factors	0	If (D=1, 0,I32)	0	0	0	0	0	0
Hhold	0	If (D=1, 0, I42)	0	0	0	0	0	0
wcollect	0	If (D=1,g5,I52)	0	0	0	0	0	0
wtyp	0	If (D=1, 0, I62)	0	0	0	0	0	0
wtreat	0	If (D=1, 0,I72)	0	0	0	0	0	0
Inst.	0	If (D=1, 0, I82)	0	0	0	0	0	0

Exogenous demand Shock Vector (H)

Table 17 Exogenous demand shock Vector (H)

	Comm
sec	0
comm	E = Exogenous demand of commodities by Exogenous Institution Accounts
Factors	0
Hhold	0
wcollect	0
wtyp	0
wtreat	0
Inst.	0

APPENDIX C- Results

The Cassava Wastage Quantum (Other studies)

In 2011, FAO estimated physical losses of roots and tubers at 40% of what is produced in Sub-Saharan Africa using a mass flow model and data from the food balance sheets reported in FAOSTAT (FAO, 2011). Although this approach distinguishes “planned” non-food uses to “unplanned” non-food uses, elicits the edible food mass using conversion factors and considers the supply chain, the data on SSA that was used were purposively sampled and outdated. To update the data used in quantifying food wastage in SSA, Parfitt et al took into account efficiency improvements in the agriculture sector over the years (2010) which estimated cassava losses at 10-25% using data from

National Academy of Sciences report (1978) and cited in FAO (1981) and adjusted for an exogenous increase in efficiency to account for technological changes that may have reduced food waste over the years. However, both studies ignore the different sources of food waste, value chains associated with various food and assumed a homogenous definition of edible food which could lead to an inaccurate measurement of food wastage.

Subsequent studies that attempted to quantify cassava wastage in Sub-Saharan Africa only considered a subset of the value chains of cassava such as gari and starch value chains in Nigeria(Oguntade, 2013), traditional gari processing in Ghana(Boahen,2004) and traditional agbelima processing in Ghana(Dziedzoave et al,1999). In a more recent study, Naziri et al estimates avoidable fresh cassava roots wastage in the cassava value chains in Ghana, Nigeria, Thailand and Vietnam using the value chain approach and elicits data using a semi/structured questionnaire of a representative sample of supply chain agents within the various value chains (2014). The study concluded that Ghana incurs by far the highest physical and economic losses as at 2012 and that the food wastage problem in Ghana is predominantly food waste. By comparing the variety of definition and situation of cassava wastage between countries, the study suggested that policymakers in tacking cassava wastage must tailor interventions to a country and the value chain.

This meta study by (Affogon, Mutungi, Sanginga, & Borgemeister, 2015) attempted to provide evidence of the nature, magnitude, costs and value of current PHL of relevant commodities from farm to fork in seven groups of commodities, cereals, pulses, fruits, roots and tubers, vegetables, animal products and oil crops, along the value chain in 6 African countries in SSA; Benin, Ghana, Kenya, Malawi, Mozambique and Tanzania. Out of 838 documents sourced from EconLit, ELDIS, PubMed,IBSS, Scopus, Science Direct, CAB direct, AGRICOLA, JSTOR, Harvest Plus, AGRIS, IDEAS and reports from national research institutions, universities, government departments, NGOs and international development organizations, only 213 documents were selected based on satisfactory-excellent methodology over the period 1980-2012[44]. However, only 6.1% covered cassava and yam which were the root and tuber commodities considered for Ghana[45]. From the simplified aggregation of the losses, by computing the means and SD of estimates, PHL losses for roots and tubers were estimated to be 43.5+/- 27.4% which was estimated to be the highest due to their perishable nature and poor post-production infrastructure for handling produce (table 3). For a homogeneous and statistically significant estimate, they also used the random effects model, which

[44] 37.9% were based on household surveys, 28.9 % on field trials and 16.1% on lab experiments.

45.6% targeted storage, 12.9% marketing, 11% on harvesting and the rest on value chains

[45] 5 literature on cassava and 9 literature on yam in Ghana

used only 21 studies[46] which estimate that PHL losses for dried cassava chips was 45.52 +/-17.5%. A limitation of these figures are that they are not corrected for storage withdrawal and do not distinguish between other cassava value products and the fresh cassava product which could be the reason for the difference between our preferred estimate and this estimate.

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[46] since85% could not meet statistical requirements of the random effects model.

Table 18 The Modified 2005 Ghana SAM (FWSAM-C)

			Sectors												**Commodity**			**Factors**					**Household_Eat**		**Waste collection**	**Waste types(waste generated by sectors)**			**Wtreat(waste treatment sectors)**					**Government**	**Capital Account**	**Rest of world**	**Total**
			acass	alocf	atrtr	Hcook_Rural	Hcook_Urban	agric	energy	aosrvs	ccass	clocf	ctrtr	Cooked Food	cagric	cenergy	cosrv	Labwork	Labcook	capa	capn	land	Hrur	Hurb	Wcollect	FCR	AGB	GAR	Reuse	Recycle	Recovery	E-landfill	Illegal dumping	gov	Investment	row	
		acass									4671.20	0.00	0.00	0.00	0.00	0.00	0.00								0.93	5.55	0.00	0.00									4677.69
		alocf									0.00	3539.95	0.00	0.00	0.00	0.00	0.00								2.66	11.05	2.45	3.98									3560.09
		atrtr									0.00	0.00	23401.47	0.00	0.00	0.00	0.00								7.99	0.00	24.42	39.56									23473.44
		Hcook_Rural									0.00	0.00	0.00	49424.85	0.00	0.00	0.00								18.18	108.10	0.00	0.00									49551.12
		Hcook_Urban									0.00	0.00	0.00	54109.38	0.00	0.00	0.00								18.62	110.73	0.00	0.00									54238.73
Sectors		agric									0.00	0.00	0.00	0.00	67079.48	0.00	0.00																				67079.48
		energy									0.00	0.00	0.00	0.00	0.00	21997.01	0.00																				21997.01

		aosrv									0.00	0.00	0.00	0.000	0.00	0.00	52575.93																				525755.93
		ccass	755.76	585.88	-63.98	2213.91	1073.33	0.00	0.00	0.00													0.00	0.00	87.02									0.00	0.00	24.82	4676.75
		clocf	0.00	228.62	0.00	1379.82	1580.13	175.72	0.00	193.14													0.00	0.00	0.00									0.00	0.00	0.00	3557.43
		ctrtr	6886.27	201.99	3885.28	611.49	1278.65	9186.67	2327.97	4462.94													0.00	0.00	0.00									2846.51	0.00	0.00	25487.75
		Cooked Food	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00													49424.85	54109.38	218.82									0.00	0.00	0.00	103753.05
Commodity		cagric	0.00	1503.93	0.00	25399.78	22907.67	8636.55	237.85	2175.58													0.00	0.00	0.00									0.00	0.00	26698.72	87560.08
		cenergy	36.14	85.52	11474.58	8432.95	11487.38	8281.48	13621.65	4647.31													0.00	0.00	0.00									0.00	15408.06	882.27	74357.33
		cosrv	0.00	0.00	628.46	2799.21	5927.18	991.70	323.21	9403.76													0.00	0.00										15473.30	12798.83	7492.09	55837.73
Factors		Labwork	2133.80	801.67	5742.88			27495.53	2665.49	22193.76																											61033.14
		Labcook	0.00	0.00	0.00	8587.69	9855.05	0.00	0.00	0.00																											18442.7

																																					4
		capa	111.10	0.00	0.00	0.00	0.00	2593.06	0.00	0.00																											2704.17
		capn	0.00	132.33	1734.25	0.00	0.00	4287.03	2820.84	9499.45																											18473.90
		land	948.12	0.00	0.00	0.00	0.00	5826.88	0.00	0.00																											6775.00
Households		hrur																28223.03	8587.69	2704.17	4023.22	6775.00	0.00	-333.30										2282.85	0.00	410.11	52672.76
		hurb																32810.12	9855.05	0.00	10339.53	0.00	333.30	0.00										2476.49	0.00	1597.51	57412.00
Generation stage	**<u>Waste collection sector</u>**	Wcollect	0.93	2.66	7.99	18.18	18.62				5.55	17.48	63.98	218.82											0.00												354.22
	<u>Waste types</u>	FCR	5.55	11.05	0.00	108.10	110.73																						22.69	22.69	116.70	59.02	-49.04		0.00		407.49
		AGB	0.00	2.45	24.42	0.00	0.00																						2.11	2.11	10.85	5.49	-4.56		0.00		42.87
		GAR	0.00	3.98	39.56	0.00	0.00																						2.93	2.93	15.07	7.62	-6.33		0.00		65.76
Treatment stage	**<u>Waste treatments</u>**	Reuse																								22.69	2.11	2.93									27.73
		Rec																								22.6	2.11	2.93									27.

		ycle																								9											73
		Recovery																								116.70	10.85	15.07									142.62
		E-Landfill																								59.02	5.49	7.62									72.13
		Illegal dumping																								-49.04	-4.56	-6.33									-59.93
Government		gov	0.00	0.00	0.00	0.00	0.00	-395.16	0.00	0.00	0.00	0.00	2022.30	0.00	5476.21	10336.89	322.89	0.00	0.00	0.00	4111.15	0.00	806.53	2375.41										22209.73	0.00	5714.23	52980.20
Capital Account		Savings									0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2108.09	1260.51										6776.40	0.00	18061.89	28206.88
Rest of world		row									0.00	0.00	0.00	0.00	15004.38	42023.43	2938.91	0.00	0.00	0.00	0.00	0.00												914.92	0.00		60881.64
Total			4677.69	3560.09	23473.44	49551.12	54238.73	67079.48	21997.01	52575.93	46767.75	35357.43	25487.75	103753.05	87560.08	74357.33	55837.73	61033.14	18442.74	27041.17	18473.90	6775.00	52672.76	57412.00	354.22	407.49	42.87	65.76	27.73	27.73	142.62	72.13	-59.93	52980.20	28206.88	60881.64	

Table 19 Technical coefficients (M)

	Sectors												**Commodity**			**Factors**					**Household_Eat**		**Waste collection**	**Waste types(waste generated by sectors)**			**Wtreat(waste treatment sectors)**					**Government**	**Capital Account**	**Rest of world**
	acass	alocf	atrtr	Hcook_Rural	Hcook_Urban	agric	energy	aosrvs	ccass	clocf	cctrtr	Cooked Food	cagric	cenergy	cosrv	Labwork	Labcook	capa	capnd	land	Hrur	Hurb	Wcollect	FCR	AGB	GAR	Reuse	Recycle	Recovery	Disposal	Illegal dumping	gov	Investment	row
acass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
alocf	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-0.25	2.62	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
atrtr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	26.02	5.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hcook_Rural	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	-2.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hcook_Urban	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	-2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
agric	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
energy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
aosrv	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ccass	0.16	0.16	-0.	0.04	0.02	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

			01							0	0									0													
clocf	0.0 0	0. 06	0. 00	0.03	0.03	0. 00	0.0 0	0. 00	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.00	0. 00	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
ctrtr	0.1 5	0. 06	0. 17	0.01	0.02	0. 14	0.1 1	0. 08	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.00	0. 00	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
Cooked Food	0.0 0	0. 00	0. 00	0.00	0.00	0. 00	0.0 0	0. 00	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.94	0. 94	0.62	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
cagric	0.0 0	0. 42	0. 00	0.51	0.42	0. 13	0.0 1	0. 04	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.00	0. 00	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
cenergy	0.0 1	0. 02	0. 49	0.17	0.21	0. 12	0.6 2	0. 09	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.00	0. 00	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
cosrv	0.0 0	0. 00	0. 03	0.06	0.11	0. 01	0.0 1	0. 18	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.00	0. 00	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
Labwork	0.4 6	0. 23	0. 24	0.00	0.00	0. 41	0.1 2	0. 42	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.00	0. 00	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
Labcook	0.0 0	0. 00	0. 00	0.17	0.18	0. 00	0.0 0	0. 00	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.00	0. 00	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
capa	0.0 2	0. 00	0. 00	0.00	0.00	0. 04	0.0 0	0. 00	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.00	0. 00	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
capn	0.0 0	0. 04	0. 07	0.00	0.00	0. 06	0.1 3	0. 18	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.00	0. 00	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
land	0.2 0	0. 00	0. 00	0.00	0.00	0. 09	0.0 0	0. 00	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.00	0.00	0. 00	0. 00	0. 0 0	0.00	0. 00	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
hrur	0.0 0	0. 00	0. 00	0.00	0.00	0. 00	0.0 0	0. 00	0. 00	0. 0 0	0. 0 0	0.00	0.00	0.0 0	0. 00	0.46	0.47	1. 00	0. 22	1. 0 0	0.00	- 0. 01	0.00	0. 00	0.0 0	0. 00	0.0 0	0.0 0	0.00	0.00	0.00	0.00	0.00	0. 00
hurb	0.0	0.	0.	0.00	0.00	0.	0.0	0.	0.	0.	0.	0.00	0.00	0.0	0.	0.54	0.53	0.	0.	0.	0.01	0.	0.00	0.	0.0	0.	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.

	0	00	00			00	0	00	00	0 0	0 0			0	00			00	56	0 0		00		00	0	00	0	0						00
Wcollect	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FCR	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.82	0.82	0.82	0.82	0.00	0.00	0.00
AGB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.08	0.08	0.00	0.00	0.00
GAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.11	0.11	0.11	0.11	0.00	0.00	0.00
Reuse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Recycle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Recovery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.08	0.35	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	0.18	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Illegal dumping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.57	-28.30	-4.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
gov	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.08	0.00	0.06	0.14	0.01	0.00	0.00	0.02	0.22	0.00	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Savings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
row	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.57	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 20 Multipliers

Constrained Sectoral multipliers	Total output Multiplier	Direct output multiplier	Indirect output multiplier	Employment multiplier	Income Multiplier	
				(work)	RuraHH	Urban HH
Cassava	3.77	1.00	2.77	0.88	0.85	0.68
Local Food Processing	3.52	1.11	2.42	0.73	0.55	0.58
Trade and Transport services	2.81	1.60	1.21	0.57	0.37	0.47
Rural Household cooking Sector	3.66	1.54	2.12	0.53	0.56	0.56
Urban Household cooking Sector	3.69	1.59	2.09	0.53	0.56	0.58
Non cassava Agriculture Sector	3.92	1.70	2.22	0.89	0.78	0.73
Energy sector	2.60	1.33	1.27	0.38	0.31	0.39
Other Services	4.05	1.37	2.68	0.95	0.71	0.85

Table 21 Shocks results

	Cassava export policy	Wastage prevention policy	Integrated waste management	Combine
Output expansion	46.82	46.48	46.56	46.48
Food Security	31.14	30.71	30.76	30.71
Economic growth	16.06	16.06	16.06	16.06
Shared Prosperity	2.11	2.09	2.08	2.09
Cooking burden	3.27	3.18	3.18	3.18
Employment	10.88	10.89	10.89	10.89
Work-Cooking Income trade off	7.61	7.71	7.71	7.71
Gross Food Wastage generation	0.15	0.08	0.15	0.08
Net Wastage generation	-0.26	-0.04	0.18	0.05
Leakages	9.73	9.74	9.75	9.74