The Impacts of Reducing Food Loss in Ghana

A scenario study using the global economic simulation model MAGNET

Martine Rutten and Monika Verma

LEI WAGENINGEN UR

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Als Ghana het voedselverlies vermindert met 50% in het jaar 2025, in alle stadia van toeleveringsketens voor rijst (paddy), fruit, groenten en noten, mais, vis en oliehoudende zaden, zijn de gevolgen voor de producenten verschillend per sector: consumenten profiteren van een lagere voedselprijs, maar als ze werken als loonarbeiders, kunnen ze inkomen verliezen.
Een efficiënter voedselproductiesysteem in Ghana zal ook resulteren in een additionele 0,8% stijging van het Bruto Binnenlands Product in 2025; een welzijnstoename-equivalent van USD19 per hoofd van de bevolking en een iets hogere calorie-inname (29 Kcal per hoofd van de bevolking).

When Ghana reduces food loss by 50% by the year 2025, at all stages of supply chains for the paddy, fruits vegetables and nuts, maize, fish and oilseeds, the impacts for producers vary across sectors; consumers gain from food price reduction, but if they are wage labourers, they might lose income. A more efficient food production system in Ghana will also result in an additional 0.8% increase in its Gross Domestic Product in 2025; a welfare increase equivalent of USD 19 per capita and a slightly higher (29 Kcal per capita) calorie intake. The study was done for the Ministry of Economic Affairs as part of its BO research programme on food waste. The aim of the research was to investigate the medium- to long-term macroeconomic impacts of tackling food losses, with Ghana serving as an informative case.

Key words: food loss; Ghana; impact

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P.O. Box 29703, 2502 LS The Hague, The Netherlands, T +31 (0)70 335 83 30,
E informatie.lei@wur.nl, www.wageningenUR.nl/en/lei. LEI is part of Wageningen UR (University & Research centre).

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Preface

It is estimated that to feed the world's population in 2050, 70% more food would have to be produced. This means that an integrated approach of action on several fronts is needed, which includes tackling food loss and waste (FLW), which are estimated to account for almost a third of food produced for human consumption globally. In low-income countries such as Ghana these losses predominantly occur at the agricultural production, post-harvest and processing stages. Each year, Ghana is estimated to lose about 20 to 30% of cereals and legumes and about 20 to 50% of roots, tubers, fruits and vegetables, in storage, during transport, or at the market.

Reducing food losses and waste is an important topic for the Dutch government. Also, the Government of Ghana has made the reduction of post-harvest losses a priority, aiming to develop a national investment plan towards this goal. The effectiveness of a such a policy has yet to be determined. This is why the Ministry of Economic Affairs has asked LEI Wageningen UR to investigate the medium- to long-term macroeconomic impacts of tackling food losses, with Ghana serving as an informative case.

Stichting Dienst Landbouwkundig Onderzoek
LEI Wageningen UR

Ms. L.C. van Staalduinen
Managing Director

Summary

S.1 Key findings

When Ghana reduces food loss by 50% by the year 2025, at all stages of supply chains for the paddy, fruits vegetables and nuts, maize, fish and oilseeds, the impacts for producers vary across sectors; consumers gain from food price reduction, but if they are wage labourers, they might lose income.

S.2 Complementary results

A more efficient food production system in Ghana will also result in an additional 0.8% increase in its Gross Domestic Product in 2025; a welfare increase equivalent of USD19 per capita and a slightly higher (29 Kcal per capita) calorie intake.

S.3 Method

The study was done for the Ministry of Economic Affairs as part of its BO research programme on food waste. The aim of the research was to investigate the medium- to long-term macroeconomic impacts of tackling food losses, with Ghana serving as an informative case.

The calculations were done using the MAGNET model, which is a multi-sector, multi-region CGE model widely used to simulate impacts of agricultural, trade, land and biofuel policies on the global economy. MAGNET is based on the Global Trade Analysis Project (GTAP) model, which accounts for the behaviour of households, firms, and the government in the global economy and how they interact in markets.

Samenvatting

S.1 Belangrijkste uitkomsten

Als Ghana het voedselverlies vermindert met 50% in het jaar 2025, in alle stadia van toeleveringsketens voor rijst (paddy), fruit, groenten en noten, mais, vis en oliehoudende zaden, zijn de gevolgen voor de producenten verschillend per sector: consumenten profiteren van een lagere voedselprijs, maar als ze werken als loonarbeiders, kunnen ze inkomen verliezen.

S.2 Aanvullende resultaten

Een efficiënter voedselproductiesysteem in Ghana zal ook resulteren in een additionele 0,8% stijging van het Bruto Binnenlands Product in 2025; een welzijnstoename-equivalent van USD 19 per hoofd van de bevolking en een iets hogere calorie-inname (29 Kcal per hoofd van de bevolking).

S.3 Methode

De studie is uitgevoerd voor het ministerie van Economische Zaken als onderdeel van het BO-onderzoeksprogramma over voedselverspilling. Het doel van het onderzoek is om de macro-economische effecten op de middellange tot lange termijn van de aanpak van voedselverliezen te berekenen, met Ghana als een informatieve case.

De berekeningen zijn gedaan met is behulp van het MAGNET-model, een multi-sector, multi-regio CGE-model dat op grote schaal gebruikt wordt om de effecten van landbouw-, handels-, grond-, en biobrandstoffenbeleid op de wereldeconomie te simuleren. MAGNET is gebaseerd op het Global Trade Analysis Project (GTAP) model, dat het gedrag van huishoudens, bedrijven en de overheid in de mondiale economie meeneemt en hoe ze op elkaar inwerken in de markten.

Acknowledgements

The authors gratefully acknowledge financial support from the Policy Supporting Research ('Beleids-Ondersteunend Onderzoek') programme of the Ministry of Economic Affairs, Theme: food losses and waste (BO-20-007-303). The authors are further grateful to Gerdien Meijerink, Michiel van Dijk, Lindsay Shutes, Daphne ter Braak and Mireille Boshuizen for their useful comments and advice. The views expressed here are those of the authors.

1 Introduction

1.1 Background

In view of the food price peaks of 2007-2008 and 2011-2012, the world is increasingly concerned with the question of how to feed the growing population, and especially the poor and vulnerable. The numbers suggest that globally, compared to 2009, 70% more food would have to be produced to satisfy the needs of a growing population by 2050 (FAO, 2009). This task is challenging due to - the competing claims on food, from feed, fuel, fibre; and increasing threat from climate change processes. Ghana as well, despite almost doubling the Gross Domestic Product (GDP) over last two decades and being on track to halving the proportion of poor and hungry people before 2015 (Millennium Development Goal 1), faces serious threats from climate change. This is expected to negatively affect the agricultural sector, currently accounting for around 36% of GDP and employing over half of the workforce (FAO, 2013; World Bank, 2010).

Feeding a growing population under such a scenario, requires an integrated approach of action on several fronts. One solution is seen in tackling food losses and waste (FLW), which are estimated to account for close to one third of food produced for human consumption globally, equivalent to around 1.3bn tonnes per year (FAO, 2011). In low-income countries, such losses predominantly occur at the agricultural production, post-harvest and processing stages, and are mainly caused by a lack of managerial, technical and financial capacity in harvesting, storage and cooling. In medium- and high-income countries, losses (more appropriately termed waste), occur primarily at the retail and final consumption stages and originate from consumer behaviour and lack of coordination in the retail chain (FAO, 2011; CFS, 2014).

DEFINITIONS

Food security is defined as '… when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO, 1996).
Food losses are defined as the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption and takes place at production, post-harvest, and processing stages in the food supply chain (Parfitt *et al.*, 2010).
Food waste is defined as food losses occurring at the end of the food supply chain at retail and final consumption stages (Parfitt *et al.*, 2010).
These definitions are in line with FAO's definitional framework of food loss (FAO, 2014).

Each year, Ghana is estimated to lose about 20 to 30% of cereals and legumes and about 20 to 50% of roots, tubers, fruits and vegetables, in storage, during transport, or at the market (ICIPE, 2013). Post-harvest cereal losses can be as high as 50 to 70% (World Bank, 2011). Whilst currently there is a problem of food losses in the early stages of the food chain, it is in future expected to change into one of waste, due to increased urbanisation, income growth and resulting changes in dietary patterns of a growing middle class. The Government of Ghana has made the reduction of post-harvest losses their priority and wishes to develop a national investment plan towards this goal, as indicated in Malabo Declaration (African Union, 2014).

It is expected that efforts to reduce FLW may benefit net food consumers, as more food may become available at lower price, and may benefit net food producers as they could generate higher incomes by selling more produce at a lower cost (FAO, 2011; Lundqvist *et al.*, 2008; Parfitt *et al.*, 2011). The theoretical[1] and empirical foundation for these claims is, however, thin. Applied studies on food loss and waste (reduction) impacts are scarce, primarily due to a lack of data. Rutten and Kavallari (2013) is one of the first empirical studies, implementing the framework set out by Rutten (2013). They investigate the impacts of reducing agricultural food losses in the Middle East and North Africa (MENA), using a Computable General Equilibrium (CGE) model called Modular Applied GeNeral Equilibrium Tool (MAGNET). The authors find that from food security perspective, the same growth target achieved by tackling agricultural food losses in MENA outperforms manufacturing and service-led growth. Their study suffered from a lack of data on costs (which were assumed absent), lack of knowledge on the nature of food losses and measures taken to reduce them (modelled via productivity gains in agriculture across the board) and did not consider food security and poverty impacts across different types of households. Rutten *et al.* (2013) is a second empirical study using the MAGNET model investigating the impacts of reducing food waste in the EU. It finds that less food waste in the EU results in land-use savings, higher consumer welfare, and a smaller agro-food sector. Impacts of food waste reduction on food security in Sub-Saharan Africa, as compared to the alternative scenario of a healthy eating pattern, are relatively small but positive. Rutten *et al.* (2013) identify the need for follow-up research to determine the results of reducing food losses in supply chain (agriculture, the processing industry, storage and transport), reducing FLW in the rest of the world, and also the need to derive more detailed distributional impacts across households.

1.2 Aim

We investigate the medium- to long-term macroeconomic impacts of tackling food losses in Ghana, focusing on outcomes in terms of economic growth, changes in production and prices for relevant commodities, impacts on households' food consumption and nutrition, and on economy-wide welfare. The findings of this project supplement the findings from the forthcoming pilot study for Ghana carried out by Wageningen UR as part of the broader Policy Supporting Research ('Beleids-Ondersteunend Onderzoek') programme. The pilot will focus on the analysis of specific underlying causes of post-harvest losses seen for specific agri-food commodities in Ghana, and will propose concrete solutions to reduce these losses. It would also gather information on costs of reducing losses in Ghana. This cost information, combined with the information on impacts resulting from this macro-economic assessment, should be able to provide a better picture about what actions (i.e. for which commodity and/or which element of the food supply chain) should be taken to reduce food losses in Ghana in the most cost-effective manner.

1.3 Approach

We employ the MAGNET model to evaluate the impacts of food loss reductions in Ghana. The scenarios will be implemented relative to a baseline which follows Shared Socioeconomic Pathway 'Middle of the Road' - SSP2 scenario) (O'Neill *et al.*, 2012). It will also draw upon recent modelling and scenario work carried out in the FoodSecure project, coordinated by LEI Wageningen UR (www.foodsecure.eu); and modelling studies on food losses and waste (Rutten, 2013; Rutten and Kavallari, 2013; Rutten *et al.*, 2013 and 2014). Data will be drawn from existing studies, available literature (FAO, 2011; ICIPE, 2013; World Bank, 2011), from projects and initiatives in Ghana currently underway or in the process of being carried out by LEI (e.g. van Dijk *et al.*, 2013).

[1] Using economic theory it can be shown that the impacts differ from the magnitude of FLW and depend, in addition, on the extent to which they are avoidable, factors that cause them to arise in the first place and the costs associated with measures to reduce them. Interactions within the food supply chain and the broader economy also affect the impacts. Trade-offs occur on the demand side where a reallocation of spending on previously wasted foods causes some producers to be worse off and some to be better off. Over time, producers tackling losses may have to incur welfare losses in the short run with gains in terms of increased revenues, if any, occurring later. Similarly, consumers may delay spending savings on previously wasted foods. As a consequence, the impacts, notably on food security and welfare, are ambiguous (Rutten, 2013).

1.4 Structure of the report

The structure of the remainder of the report is as follows. Section 2 gives a background of the Ghanaian context using existing literature with particular attention to food security in relation to what is known (data) on food losses and waste in Ghana. This will be used as an input into the modelling exercise. Section 3 describes the methodology, including the MAGNET model and the scenarios. Section 4, 5 and 6 contain the results, discussion and conclusions, respectively.

2 Food security and food losses and waste in the context of Ghana

2.1 The state of food security in Ghana

Food security is most commonly defined as '…when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO, 1996). Ghana's achievements when it comes to food and nutrition security over the last decade(s) have been mixed.

On the positive side, Ghana has achieved an impressive annual rate of economic growth of 5% since 2001, fostered by political stability, higher gold and cocoa prices and a healthy investment climate backed up by donor-supported economic programmes and reforms (FAO, 2013). Many of the reforms and investments targeted the economy's most important sector, agriculture, which employs over half of the country's workforce. Most notable beneficiaries were cocoa, vegetables and fruit. This resulted in an increase in food production by smallholder farmers of on average 55% since the early 1990s. Since then about 5 million Ghanaians were lifted out of poverty, notably in rural areas, and rates of undernourishment fell to less than 5% of the population in 2011-2013. Ghana also met its MDG hunger target by early 2000 and is on track to meet its poverty target by 2015 (FAO, 2013).[2]

On the negative side, Ghana has made less progress in terms of reducing undernutrition.[3] While the proportion of children under five who are underweight declined from 25% in 1994 to 13% in 2011, the proportion of children under five who are stunted remained relatively high, around 33% in 1994 compared with 22% in 2011 (FAO, 2013). Main causes are said to be poverty, disease, poor maternal and child health services, lack of sanitation and access to safe water. Moreover, regionally and locally poverty and nutrition outcomes differ markedly, with rural areas faring much worse.

2.2 Food security in Ghana: areas of concern

The Food Security Index developed by the Economist Intelligence Unit (EUI, 2014) measures food security along the three dimensions of availability, affordability, and quality and safety, and is able to highlight underlying strengths and challenges. According to this index, Ghana reached an average score of 43% out of 100 in 2014 (Figure 1). This places Ghana in the bottom 28% of the index as a 'moderate' performer, with a ranking of 78th out of 109 countries in total. Compared to other countries in the Sub-Saharan African region, Ghana ranks fifth out of 28, behind South Africa, Botswana, Uganda and Cote d'Ivoire. Looking at the three dimensions of the score, especially affordability (score of 37.4% out of 100; ranking 84th out of 109) seems to be its biggest problem.

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[2] In line with FAO (2013), we use the following definition of undernourishment and hunger: undernourishment is a 'state, lasting for at least one year, of inability to acquire enough food, defined as a level of food intake insufficient to meet dietary energy requirements'. Hunger is defined as 'a state of chronic undernourishment'.

[3] Defined by FAO (2013) as 'the outcome of undernourishment, and/or poor absorption and/or poor biological use of nutrients consumed as a result of repeated infectious disease'. It includes being underweight for one's age, too short for one's age (stunted), dangerously thin for one's height (wasted) and deficient in vitamins and minerals (micronutrient malnutrition).

"=" before the rank indicates a tie in rank with another geography.

	Score / 100			Rank / 109		
	2012	2013	2014	2012	2013	2014
OVERALL SCORE	42.5	42.3	**43.1**	75	75	**78**
1) AFFORDABILITY	37.0	34.2	**34.7**	75	79	**84**
2) AVAILABILITY	47.9	48.9	**48.3**	71	=67	**=71**
3) QUALITY AND SAFETY	41.2	44.6	**49.8**	84	77	**70**

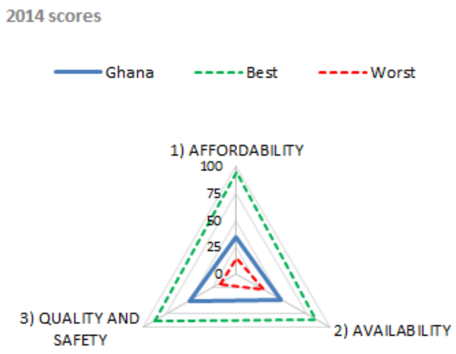

Figure 1 *Food security index - Ghana, 2014.*
Source: EUI (2014). Note: the ranking consists of 109 countries, ranked from best (1) to worst (109). Point of departure is the definition of food security specified during the 1996 World Food Summit. The index measures core issues of food security along the dimensions of affordability, availability and quality, constructed from 28 sub-indicators on a normalised scale of 0 (country with the lowest score) to 100 (country with the highest score). The indicators are weighted according to an average of suggested weights of five members of an expert panel. The index is updated over time to adjust for food price fluctuations.

Areas of affordability in which Ghana is particularly underperforming vis-à-vis the world average (Figure 2) include: access to finance for farmers (a score of 33.7% below average), food consumption as a share of household expenditure (equals 51% in Ghana, which is a score of 25.4% below average) and the proportion of the population below the poverty line of 2 dollars a day (which is 52% in Ghana, a score of 25.4% below average).

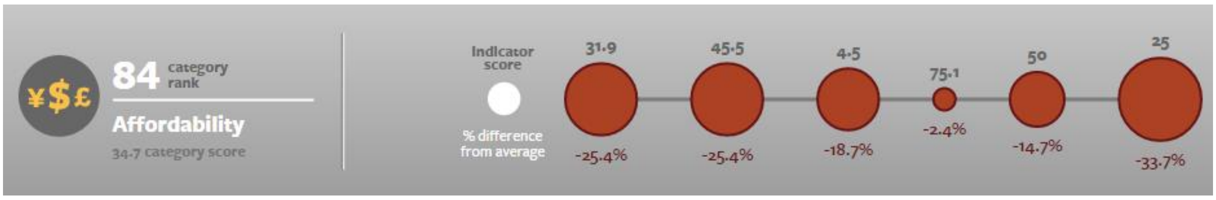

Figure 2 *Food security index - Ghana, 2014: affordability indicator score.*
Source: EUI (2014). Note: from left to right scores on: 1) food consumption as a share of household expenditure; 2) proportion of population under global poverty line; 3) GDP (ppp); 4) Agricultural import tariffs; 5) Presence of food safety nets; 6) Farmers' access to finance. Top: indicator scores, bottom: in% differences from the world average.

According to the index, the main area of concern is the existence of food losses (score of 0 out of 100), followed by a low GDP per capita, public expenditure on R&D in agriculture and protein quality (Figure 3). The low score on food losses is based on an estimate of food losses in agricultural production, post-harvest and processing stages as a percentage of total domestic supply in tonnes of 19%, using FAO data, the highest percentage of food losses of all countries in the index.

STRENGTHS (Scores 75 or more)	
3.2) Nutritional standards	100.0
2.4) Volatility of agricultural production	91.0
3.5) Food safety	75.4
1.4) Agricultural import tariffs	75.1

WEAKNESSES (Scores less than 25)	
3.4) Protein quality	19.1
2.2) Public expenditure on agricultural R&D	12.5
1.3) Gross domestic product per capita (PPP)	4.5
2.8) Food loss	0.0

Figure 3 *Food security index - Ghana, 2014: strengths and weaknesses.*
Source: EUI (2014). Note: sub-indicators of the index are reported here on which Ghana performs relatively well (left-hand side) and relatively weak (right-hand side), respectively.

2.3 Evidence on food losses and waste in Ghana

Reliable evidence on food losses and waste is generally hard to come by. The most frequently used source of international data is FAO (2011), containing worldwide food loss and waste estimates by region, commodity group, and stage of the food supply chain. These regional food loss and waste data for Sub-Saharan Africa reveal that food losses and waste in Sub-Saharan Africa are relatively high in agricultural production, post-harvest handling and storage and processing and packaging stages (Table 1, first three columns). In terms of crops, roots and tubers, and fruits and vegetables face disproportionately larger losses (Table 1, second and fourth row, highlighted). Food waste in final consumption is relatively unimportant (5% or less; last column).

Table 1
Food loss and waste data for Sub-Saharan Africa (%)

Commodity\Stage of Food Supply Chain	Agricultural Production	Post-harvest handling and storage	Processing and packaging	Distribution	Consumption
Cereals	6	8	3.5	2	1
Roots and tubers	14	18	15	5	2
Oilseeds and pulses	12	8	8	2	1
Fruits and vegetables	10	9	25	17	5
Meat	15	0.7	5	7	2
Fish and seafood	5.7	6	9	15	2
Milk	6	11	0.1	10	0.1

Source: FAO (2011).

More detailed data are available for Ghana from a review study of post-harvest losses in Africa by ICIPE (2013), for specific commodities at different stages of food supply chain, but excluding the stage of final consumption (Table 2; data grouped according to the same headings as Table 1).
Compared to Table 1, estimates of food losses in Ghana for many commodities seem much different in comparison to the regional averages for Sub-Saharan Africa. For the agricultural production and post-harvest handling and storage stages the loss estimates are much lower, while they are quite higher for the distribution stage. Notable outliers are the losses of fish and rice during processing and packaging (65 and 43% respectively). Data for Ghana illustrates that food loss and waste patterns differ a lot across commodities within the same commodity group, e.g. maize and rice are both cereals but while 43% of rice is lost during processing and packaging the figure for maize is only 1.2%. Interestingly, ICIPE (2013) reports that with specific post-harvest innovations certain categories of food loss could be reduced by 24 to 60%, but this varies a lot by type of innovation, commodity, and stage of the food supply chain.

Table 2
Food loss data for Ghana (%)

Commodity\Stage of Food Supply Chain	Agricultural Production	Post-harvest handling and storage	Processing and packaging	Distribution
Maize	4.3	6.2	1.2	4.8
Rice	2.4	5.2	43.0	1.5
Cowpea	0.0	2.9	0.0	15.0
Cassava	5.4	2.5	5.8	13.0
Yam	4.9	12.8	0.1	12.9
Mango	4.5	8.7	3.5	23.8
Oranges	1.1	2.2	0.0	2.8
Tomato	5.7	28.6	0.0	32.1
Okra	16.6	30.0	0.0	4.7
Fish	2.8	2.5	65.2	15.6
Groundnuts	1.1	1.9	1.5	2.2

Source: adjusted from ICIPE (2013). Notes: reported food loss data generally cover a range, which have been converted to simple averages. Where data are reported from different data sources, the most recent source was taken. Agricultural production covers the categories of harvesting and on-farm assembling; Post-harvest handling and storage covers preliminary processing, grading and sorting and storage categories; processing and packaging covers packaging and bagging and processing categories; distribution covers transport to storage, market and marketing/on-market storage stages; food waste in final consumption was not reported.

The World Bank (2011) focuses on post-harvest losses in grains. The African Postharvest Losses Information System (APHLIS) data system that underlies this study, and draws its data from national researchers, typically finds food loss estimates well below 40 to 50%. They are however still significant, estimated at around USD 4bn per year, or about 15% of total value of Ghanaian output of grains (USD27bn). Estimates on grain losses for Ghana from this source (Table 3) reveal that most of the losses occur in the agricultural production and post-harvest handling and storage phases. The data for maize and rice are similar to those reported by ICIPE (2013; see Table 2), with the exception of processing and packaging for rice, which is estimated to have a loss percentage of 0.1%, compared with 43% reported by ICIPE. This is due to the fact that information on the processing of rice is missing in the World Bank study, but is included by ICIPE.

As ICIPE provides the most comprehensive data, we use Table 2 as the basis to calculate loss percentages for the commodity aggregations used in the MAGNET model. The actual numbers calculated are shown in Figure 6.

Table 3
Grain loss data for Ghana (%)

Commodity\Stage of Food Supply Chain	Agricultural Production	Post-harvest handling and storage	Processing and packaging	Distribution
Maize	4.3	3.9	1.2	4.6
Rice	0.9	5.1	0.1	1.2
Millet	1.7	3.0	0.3	0.7
Sorghum	0.8	2.8	0.3	0.9

Source: adjusted from World Bank (2011). Notes: the data represent simple averages of post-harvest losses in the major and minor seasons. Agricultural production covers categories of harvesting and on-farm assembling; Postharvest handling and storage covers temporal processing, grading and sorting and storage at home/farm categories; processing and packaging covers packaging and bagging categories; distribution covers transport to home, loading to vehicle, transport to market, unloading from vehicle and market storage stages; food waste in final consumption was not reported.

3 Methodology

This study employs a scenario analysis to investigate the impacts of food loss reduction in Ghana. Scenario analysis is an important tool to help policy makers, researchers, and other stakeholders to envision what the future may look like, and guides the formulation of policies that are contingent on future expectations. We specifically implement a set of food loss reduction scenarios which demonstrate what would happen if food losses in Ghana in rice, other grains (consisting mostly of maize), vegetables, fruits and nuts, oil seeds and fish in the stages of agricultural supply (comprising agricultural production and post-harvest handling and storage), processing (including packaging), and distribution, are reduced by 50% by the year 2025. This target is in line with the Malabo declaration on accelerated agricultural growth and transformation for shared prosperity and improved livelihoods (African Union, 2014). These 'what if' scenarios are run with the MAGNET model, and compared to a reference baseline scenario, reflecting the 'Business as Usual' (BaU). The results thus illustrate the impacts of a 50% reduction in Ghanaian food loss on various socio-economic indicators in 2025, all else being equal. Impacts on certain key macroeconomic variables by 2050 are also reported. The following subsections discuss the methodology in more detail.

3.1 MAGNET model and data

MAGNET is a multi-sector, multi-region CGE model widely used to simulate impacts of agricultural, trade, land and biofuel policies on the global economy (Woltjer *et al.*, 2014). MAGNET is based on the Global Trade Analysis Project (GTAP) model, but can be extended in various directions depending on the policy questions at hand. GTAP accounts for the behaviour of households, firms, and the government in the global economy and how they interact in markets (Figure 4). It includes the food supply chain represented by agricultural sectors, food-processing industries and food-service sectors, and final consumption, taking into account bilateral trade flows (Hertel, 1997).

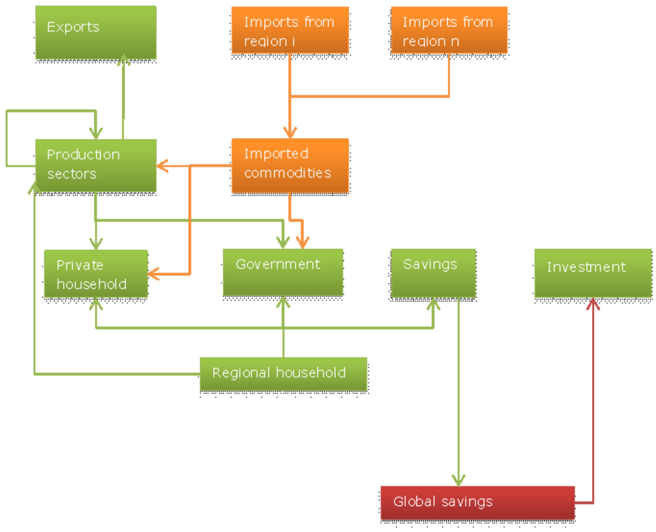

Figure 4 *A simplified representation of the GTAP model.*
Source: Woltjer et al. (2014).

The GTAP database[4] version 8.1, which reflects the state of the world economy in the year 2007, is used as a starting base for our model.

3.2 Scenarios

3.2.1 Business as Usual scenario

We first need to project our model into the future to portray the world economy in the years 2025 (the target year as identified in Malabo Declaration) and 2050 (for a longer term perspective). The picture of this future world, is taken from the SSP2 scenario. SSP2 is one of five potential futures that are increasingly being used in climate change analyses (O'Neill *et al.*, 2012), as a basis for foresight in the area of sustainable food and nutrition security (Valin *et al.*, 2014; van Dijk and Meijerink 2014). SSP2 looks at the path if we go on with "Business as Usual".

Business as Usual: SSP2 'Middle of the Road' Narrative
In this world, trends typical of recent decades continue, with some progress towards achieving development goals, reductions in resource and energy intensity at historic rates, and slowly decreasing fossil fuel dependency.

Development of low-income countries proceeds unevenly, with some countries making relatively good progress while others are left behind. Most economies are politically stable with partially functioning and globally connected markets. A limited number of comparatively weak global institutions exist. Per-capita income levels grow at a medium pace on the global average, with slowly converging income levels between developing and industrialised countries. Intra-regional income distributions improve slightly with increasing national income, but disparities remain high in some regions. Educational investments are not high enough to rapidly slow population growth, particularly in low-income countries.

Achievement of the Millennium Development Goals is delayed by several decades, leaving populations without access to safe water, improved sanitation, medical care. Similarly, there is only intermediate success in addressing air pollution or improving energy access for the poor as well as other factors that reduce vulnerability to climate and other global changes.

Source: O'Neill et al. (2012).

As the complete narrative for SSP2 (see box above) shows, observed past trends continue into the future. This future world is implemented in the model by translating it into the model variables. Future projections for relevant economic variables under this scenario, have been quantified by the Organisation for Economic Co-operation and Development and International Institute for Applied Systems Analysis. We use their projections to take our model from 2007-2014 and then onwards from 2014 to 2025, and 2025 to 2050. The exogenous yield changes were derived from FAO projections by Bruinsma (2003) and corrected to take into account differences between macroeconomic growth in the SSP2 scenario compared with FAO projections, and also adjusted for endogenous, economically driven, intensification. The reference scenario assumes no policy changes in the simulation periods, but only applies existing policies and those agreed upon for the future such as milk quota abolition in the EU and mandatory biofuel targets in 2020 worldwide.

[4] The database is fully documented (Narayanan et al., 2012) and contains comprehensive and consistent data on production, consumption and trade between countries in the world.

3.2.2 Food loss scenarios

This study uses ICIPE (2013) data on food losses in rice, maize, vegetables, fruits and nuts, and fish in Ghana, reported on in Table 2. Detailed ICIPE data are mapped to the broader sectoral aggregates available for use in MAGNET. The associated food loss percentages for the broad aggregates are calculated using FAO production volumes (tonnes) as weights. The results are displayed in Figure 6.

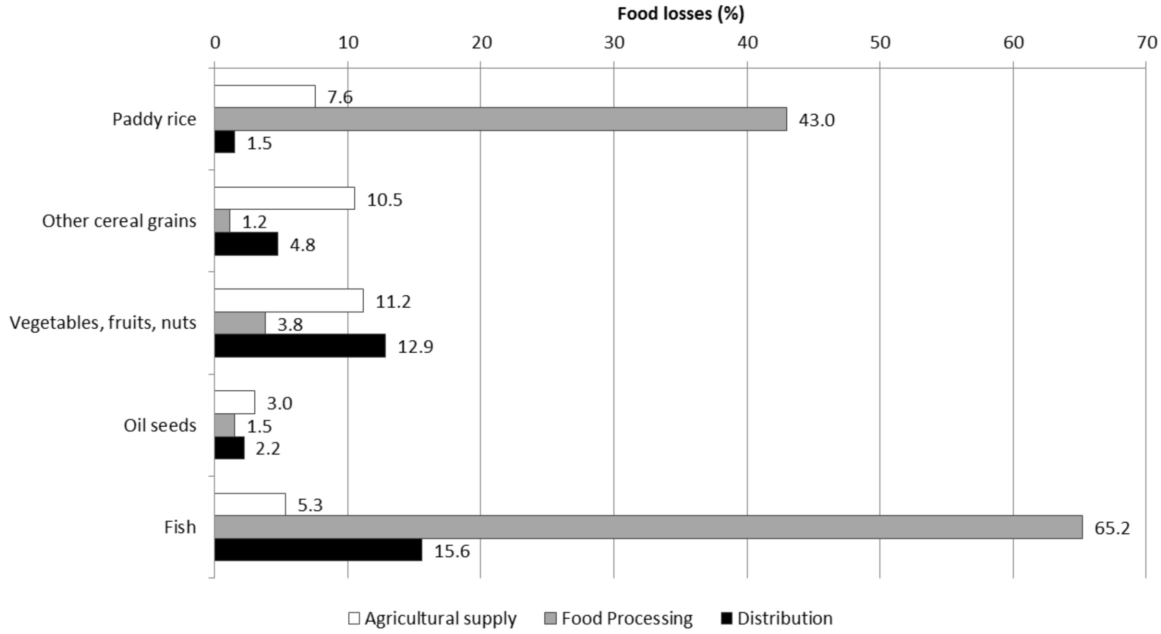

Figure 6 *Ghanaian food losses by commodity category and supply chain stage in MAGNET (%).*
Notes: Based on FAO production data 'other cereal grains' produced in Ghana consists for 74% of maize and thus adopts the food loss percentages of maize reported in Table 2; 74% of 'vegetables, fruits and nuts' produced in Ghana consist of cassava, yam, mango, oranges, tomatoes and okra and so adopts the weighted average of the food loss percentages of these sub-categories reported in Table 2; ground nuts account for almost half (45%) of 'oil seeds' produced in Ghana, the latter category is assumed to adopt the already fairly low food loss percentages of ground nuts. 'Fish' and 'rice' adopt the original loss percentages of Table 2. The bar for 'agricultural supply' displays the total of food losses in agricultural production and post-harvest handling and storage of Table 2.

Using these data, food loss reductions are modelled via productivity shocks. Tackling food losses, given inputs into production, increases outputs of agri-food sectors, or, given outputs, reduces the use of inputs into the production of these sectors. We reduce the loss percentages shown in Figure 6 by 50% in 2025, the target set by the African Union (African Union, 2014; Malabo Declaration). This is done by means of increasing the productivity, in the production, processing and distribution sectors for the food category in question.

In the first stage of agricultural supply, we assume uniform productivity increases for all inputs (i.e. the shocks are implemented as total factor productivity shocks) as we do not know if food losses occur in the use of a certain factor (e.g. labour) or intermediate input (e.g. seeds), and we do not know the nature of the tool employed to tackle food losses. This approach was first developed and used by Rutten and Kavallari (2013). In the second stage of food processing, we assume a productivity increase of certain intermediate inputs used to make a specific processed food (e.g. use of paddy in processed rice). In the third stage of distribution, we assume an increase in productivity of certain intermediate inputs used by the distribution sector (e.g. processed rice use by retail or restaurants). For all stages, the model subsequently determines the optimal input-output mix. The productivity shocks will be implemented for the period starting from the current year, 2014, up to 2025 which is the target year for achieving a 50% reduction in food loss, as set by the African Union. The resulting five scenarios, one for each commodity type, are summarised in Table 4.

Table 4

Ghana food loss reduction scenarios: productivity shocks for a 50% reduction in food losses by commodity implemented in 2014-2025

Stage of Food Supply Chain (FSC):	Agriculture		Food processing		Distribution	
Shocks (% change) applied by commodity and stage of FSC	**Output-augmenting technological change applied to:**		**Intermediate input-augmenting technological change applied to:**		**Intermediate input-augmenting technological change applied to:**	
Rice	All input use in paddy rice production	3.8	Paddy rice use in processed rice	21.5	Processed rice, distribution	0.8
Maize	All input use in maize production	5.3	Other cereal grains use in other processed food	0.6	Other processed food, distribution	2.4
			Other cereal grains use in beverages	0.6	Beverage, distribution	2.4
Vegetables, fruits and nuts	All input use in vegetables, fruits and nuts production	5.6	Vegetables, fruits and nuts use in other processed food	1.9	Vegetables, fruits and nuts, distribution	6.4
Vegetable oils	All input use in oil seeds production	1.5	Oil seeds use in vegetable oils and fats	0.8	Vegetable oils and fats, distribution	1.1
Fish	All input use in fisheries	2.7	Fish use in other processed food	32.6	Fish, distribution	7.8

To interpret the numbers in Table 4, consider the first row (rice). A 50% reduction in loss for rice in Ghana means that the use of all inputs in the production of paddy rice in Ghana can be reduced by 3.8% while maintaining the same production level for paddy crop. Similarly, the Ghanaian rice processing sector can produce the same amount of processed rice, using 21.5% less paddy rice (and the same amount of other inputs). Finally, 0.8% less of processed rice can be used in Ghana by retail, wholesale, hotels and restaurants (together called distribution) without any loss in output of distribution sector. Note that maize crop is used by 'other processed food' as well as beverages as an input.

4 Results

Below, we report the impacts of food loss reductions in Ghana for the five commodity categories as identified in the previous section (Table 4), and for an overall scenario including food loss reductions for all crops and fish. The share of these commodities in production and consumption in Ghana, provides a perspective on their importance for the economy. These five groups together constitute about 25% of production and 48% of Ghanaian consumption; with vegetables, fruits and nuts accounting for the biggest share of both the production and consumption (about 16% and 30% respectively).

We present the results of our simulations from the perspective of the different agents involved - producers, consumers, and for the economy as a whole. We report outcomes as differences from the Business as Usual scenario in 2025. For key macroeconomic variables we also report outcomes in 2050.

4.1 Tackling food loss in the Ghanaian rice chain

With food loss in the rice sector reduced by 50%, we see an increase in Ghanaian production of paddy by 5% and of processed rice by 10%. The associated revenues for the paddy and rice producers increase by 1 and 5% respectively.
Price of paddy as paid by Ghanaian consumers falls by about 3-4% and not much change is seen in the price of processed rice in Ghana. The income of households working as unskilled labour in the two sectors increases by 1% (paddy production) and 10% (processed rice). The consumption demand for paddy and rice increases by 0.4% and 0.08% respectively.

This scenario focuses on the impacts of reducing Ghanaian food losses in rice by 50% in 2025. More specifically, production losses in paddy rice are reduced. This makes the production of paddy rice more efficient and paddy is also used more efficiently at all stages in the food chain - rice processing sector becomes more efficient in processing paddy into rice, and the distribution of processed rice in Ghana also becomes more efficient (Table 4, first row).

4.1.1 Impacts on rice producers

By reducing rice loss, producers in Ghana reduce their unit costs of production. This can be seen by the fact that while production of paddy and processed rice go up by 5 and 10% respectively, the associated costs of production for the two increase by only 1 and 5%. As a result, unit costs fall by 3 and 5% respectively. The decrease in costs of producing an unit of rice, leads to lower price for rice (with perfect competition and the zero profits assumption, prices and unit costs are the same).

With paddy rice as an input for processed rice production, accounting for over a quarter of the production costs, and processed rice producers using less paddy rice to produce the same amount of rice, demand for paddy as an intermediate input falls by about 9%. In combination with the market price (unit cost) for paddy being 3% lower, reduced demand for paddy results in a reduction of its share in cost of producing processed rice (a reduction of 12%). However, increased production and therefore sales more than make up for the price fall. As a result, farmers' revenues in paddy and processed rice increases by 1 and 5% respectively (Figure 7).

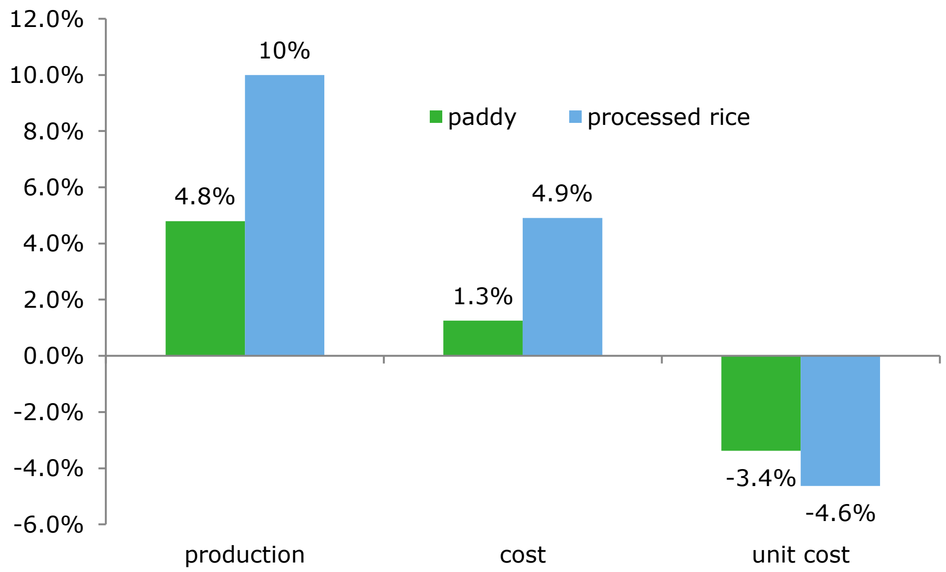

Figure 7 *Impacts on producers in Ghana in 2025 - rice loss scenario (percentage difference from the baseline).*

Amongst the primary factors of production, unskilled labour accounts for a cost share in paddy and processed rice of over 50 and 20% respectively. When rice producers start producing more rice, as our results indicate, they also demand more unskilled labour: 1% more in the paddy rice sector and 10% more in the processed rice sector respectively. Therefore, positive effects could be expected for employment in this sector due to reducing rice loss (more on these macro effects in the final, overall scenario).

4.1.2 Impacts on consumers

As a result of rice loss reductions, prices paid by consumers in Ghana for paddy rice and processed rice fall by 3.5 and 0.8% respectively. The price of processed rice for consumers falls much less, because most of processed rice is actually imported and not produced domestically. So owing to a lower share of domestically produced processed rice in total processed rice consumed, a lower portion of the price reduction is transmitted to consumers. As a result of decline in prices, the demand for paddy rice and processed rice by consumers increases by 0.4 and 0.08% respectively.

With such small increases in demand, we do not expect see much change in calorie intake of Ghanaian population. Specifically, the calorie intake per capita per day in Ghana increases by about 0.4%.
The changes in the rice chain will also impact consumers as suppliers of skilled and unskilled labour. Specifically, because demand for unskilled labour increases (section 4.1.1), income of unskilled labour increases by about 1 and 10% in paddy rice and processed rice sectors respectively (Figure 8).

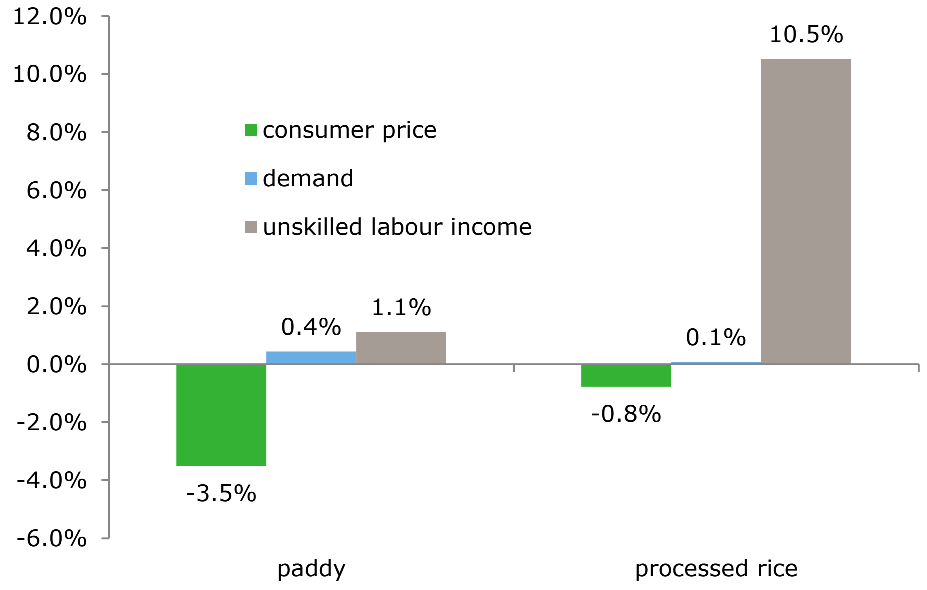

Figure 8 *Impacts on consumers in Ghana in 2025 - rice loss scenario (percentage difference from the baseline).*

4.2 Tackling food loss in the Ghanaian other cereals/maize chain

A 50% maize loss reduction in all stages of supply chain translates into a 1% increase in Ghanaian maize output. But revenue of maize producers fall by 5%.
The consumers pay a price that is 6% lower than it would be otherwise and their demand increases by 1%. Households that work as unskilled labourers to produce maize see a 4% decline in their income.

As already stated maize constitutes the majority (over 70%) of 'other cereals' production in Ghana, so we focus on reduction of food waste in maize chain. The chain involves maize production, use of maize as input for producing 'other processed food' and 'beverages', and finally the distribution of the latter two by the retail and restaurant industry.

4.2.1 Impact on maize producers

With the reduction in maize production loss, we see the maize production in Ghana increase by 1% but unlike for rice, total cost of production as well as unit cost of production both fall, by 5 and 6% respectively. Clearly more maize is being produced using less inputs - unskilled labour is the most important input, accounting for over 60% of production costs of maize, and we see the demand for unskilled labour fall by 4% as a result of reduction in loss in maize production. But the increase in production (1%) is not enough to compensate for the fall in market price of maize (6%) and we see a 5% reduction in revenue.

The importance of maize as an input into 'other processed food' and 'beverages' categories however is not big in Ghana, with cost share of maize being only 0.01 and 0.03% respectively, for the two processed food categories. Therefore we do not see big changes in production or costs of these categories when the maize price falls and maize is used more efficiently in the production of ‘other processed food’ and beverages. The impacts on price, costs and per unit costs of the two food categories are therefore shown in Figure 9 but not discussed in detail.

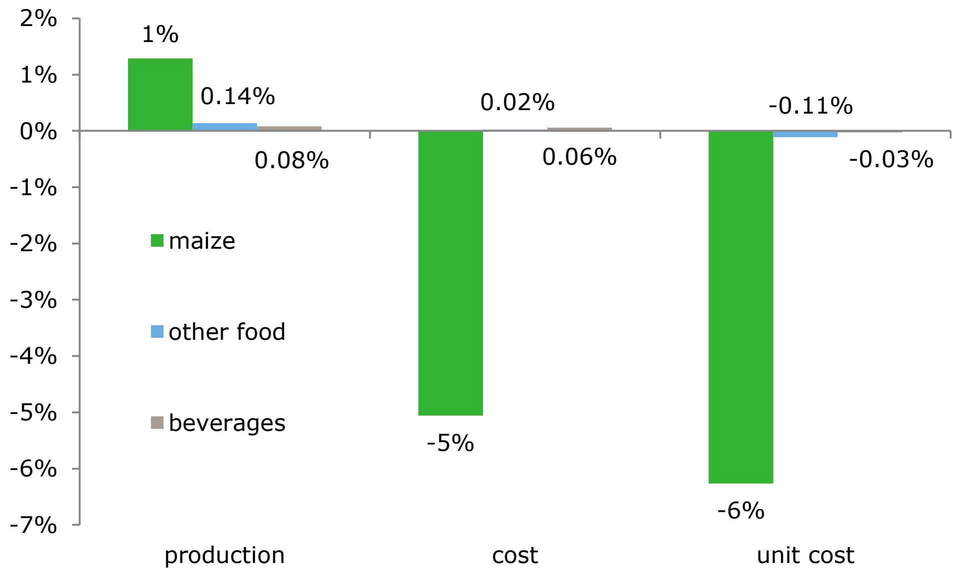

Figure 9 *Impacts on producers in Ghana in 2025 - maize loss scenario (percentage difference from the baseline)*

4.2.2 Impact on consumers

A 6% fall in the price of maize makes consumers in Ghana demand and consume more maize, increasing the demand for maize by 1%. As already stated in the discussion about impact on producers, demand for unskilled labour in maize production falls by about 4% and so does the income that households (as owners of unskilled labour) earn from working in the maize sector. A small increase in maize demand does not change the calorie intake.

We saw that food loss reduction in maize and more efficient use of maize in producing 'other processed food' and beverages, did not have a large impact on production of maize and 'other processed food' and beverages. Accordingly, we do not see any big changes in their consumption or prices either.

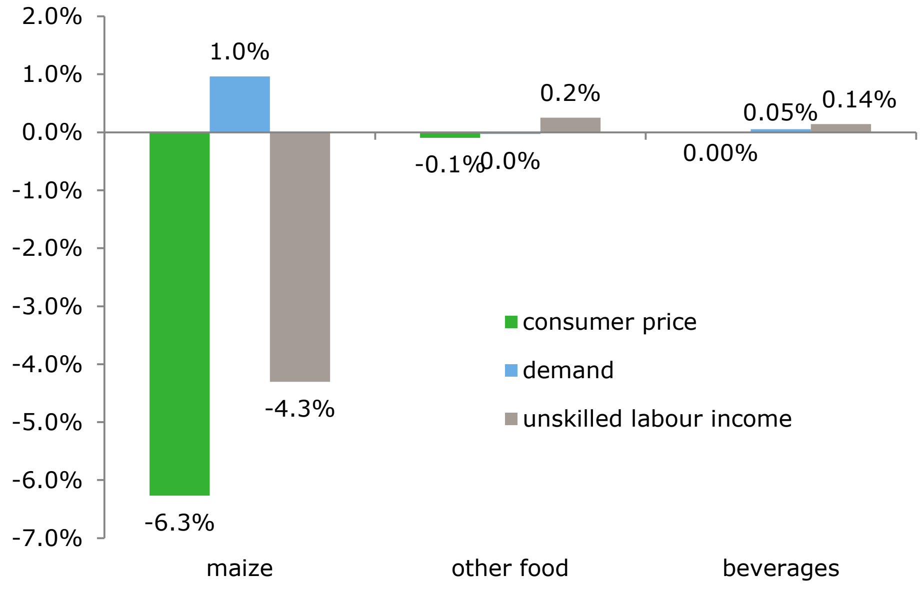

Figure 10 *Impacts on consumers in Ghana in 2025 - maize loss scenario (percentage difference from the baseline).*

4.3 Tackling food loss in the Ghanaian vegetables, fruits and nuts chain

A loss reduction in fruits, vegetables and nuts in Ghana results in a rise in production by 3% and a fall in revenues by 5%.
Consumers pay 7% less for the price for fruits, vegetables and nuts, and consume more fruits-vegetables and nuts, but unskilled labour in the sector also earns 4% less income than previously.

Vegetables, fruits and nuts production account for about 10% of value of total output in Ghana and 23% of consumption expenditure. It is therefore the most important food category for both producers and consumers in Ghana. The stages of the chain that reduce loss, are production, use of vegetables, fruits and nuts to produce 'other processed food', and distribution of vegetables fruits and nuts by retail and restaurants.

4.3.1 Impact on fruits and vegetable producers

Production of fruits, nuts and vegetables in Ghana increases by 3% as a result of food loss reduction at the different stages of food chain involving production and use of fruits, vegetables and nuts. Despite the increase in production, the total cost of production falls by 5% and as a result, the unit of cost production (and market price) falls by 7%. Like other agriculture products, unskilled labour accounts for almost 50% of cost of production of fruits, vegetables and nuts, and we see a 3% reduction in demand for unskilled labour in the sector. A 5% reduction in costs of production, with assumption of 'perfect competition' also translates into a 5% reduction in revenue for the fruit, nuts and vegetable producers.

Fruits, nuts, and vegetables also account for about 25% of costs of production of 'other processed food'. As this sector becomes more efficient in its use of fruits, nuts, and vegetables as inputs, it demands less of those inputs. We see a 0.5% reduction in demand for fruits, nuts, and vegetable inputs into 'other processed food'. With reduced input demand and lower input price, the total cost of fruits and vegetables to 'other processed food' falls by 8%. But the total costs of production (and revenue) for the sector rise by 0.2% on account of increased production (1.5%) and increase in demand of its other major input - unskilled labour, which accounts for 28% of cost of production and sees its demand increase by 1.5%. The market price and unit cost of producing 'other processed food' as a result falls by 1.3%.

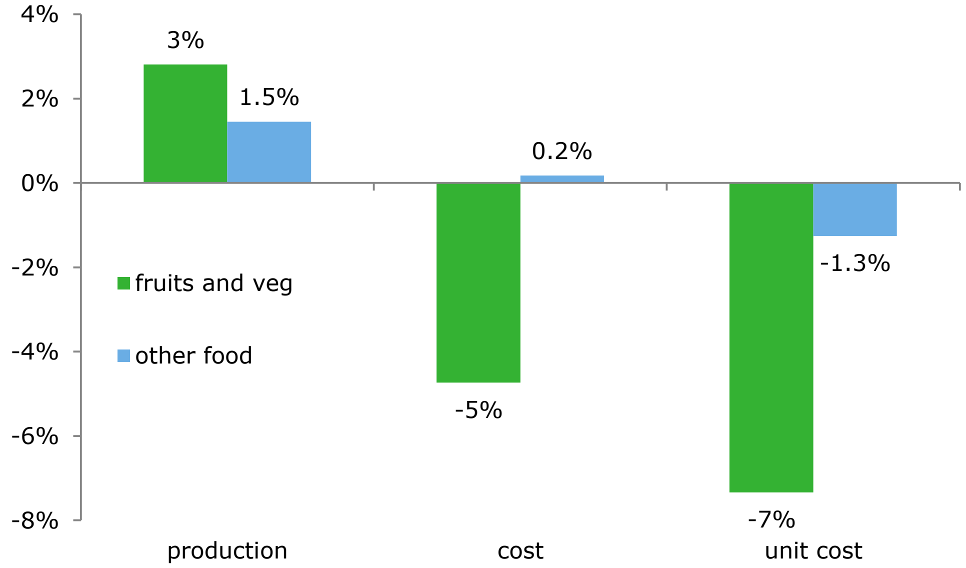

Figure 11 Impacts on producers in Ghana in 2025 - vegetables, fruits and nuts loss scenario (percentage difference from the baseline)

4.3.2 Impact on consumers

With a reduction in price of vegetables, nuts, and fruits, we see the demand for it go up by 2%. The demand for the 'other processed food' category however witnesses a fall, even though very a modest one (-0.09%). Details show that sales of some other commodities in Ghana increase (including a 0.3% increase in demand for beverages). This comes from the general equilibrium impacts - when fruits and vegetables become cheaper, demand for those cheaper inputs into beverages also increases. We see the price of beverages fall more than that of 'other processed food' and therefore see the consumption of beverages expand. In terms of per capita per day calorie intake, we see an increase of about 30 calories, which is not much when seen as percentage change from the BaU.
With a reduced demand for unskilled labour in the vegetable, fruits and nuts production, the unskilled labour income from this sector falls. Use of unskilled labour in 'other processed food' producing sector increases by about 2% and that is the result we see in terms of increased earnings of unskilled labour employment in the production of 'other processed food'.

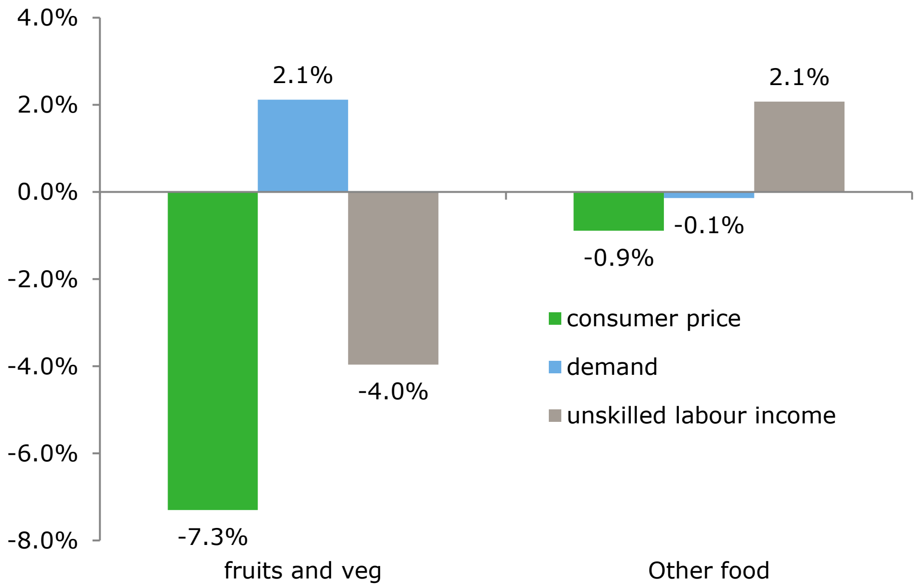

Figure 12 *Impacts on consumers in Ghana in 2025 - vegetable, fruits and nuts loss scenario (percentage difference from the baseline)*

4.4 Tackling food loss in the Ghanaian vegetable oils chain

Production of both oil seeds and vegetable oil increases by about 2%. Revenues in both sectors also increases, less so for oil seeds producers (0.05%) than for vegetable oil producers (1.3%). Consumers pay a lower price (1.5% less) and consume slightly more oil seeds (0.2% increase). The impact on unskilled labour income is modest in both the sectors.

Food loss reduction in the edible oil chain involves a reduction in production loss in oilseeds; more efficient use of oilseeds in production of vegetable oil, and cutting losses of oil at the distribution stage. This commodity group account for about 3% of consumer expenditure in Ghana in 2014.

4.4.1 Impact on vegetable oil producers

Reduction of loss in oilseeds and vegetable oil in Ghana results in a 2% increase in oilseeds output with only a modest increase (0.05%) in costs of production. This translates into a reduction of about 2% in unit cost of oilseed production. Over 50% of production costs in the oilseeds sector are accounted for by unskilled labour and use of unskilled labour in the sector increases by only 0.13%. Oilseeds account for about 75% of expenditure on inputs by the vegetable oil sector. A reduction in the oilseed price and more efficient use of oilseeds in production of vegetable oil, results in a 1.4% increase in demand for oilseeds by the vegetable oil producing industry. But due to a lower price of oilseeds, the expenditure on oilseeds as an input is only 0.8% higher. The demand for unskilled labour in the sector increases by about 2%. For producers in both sectors revenues increase even though market prices fall, because they produce and sell more.

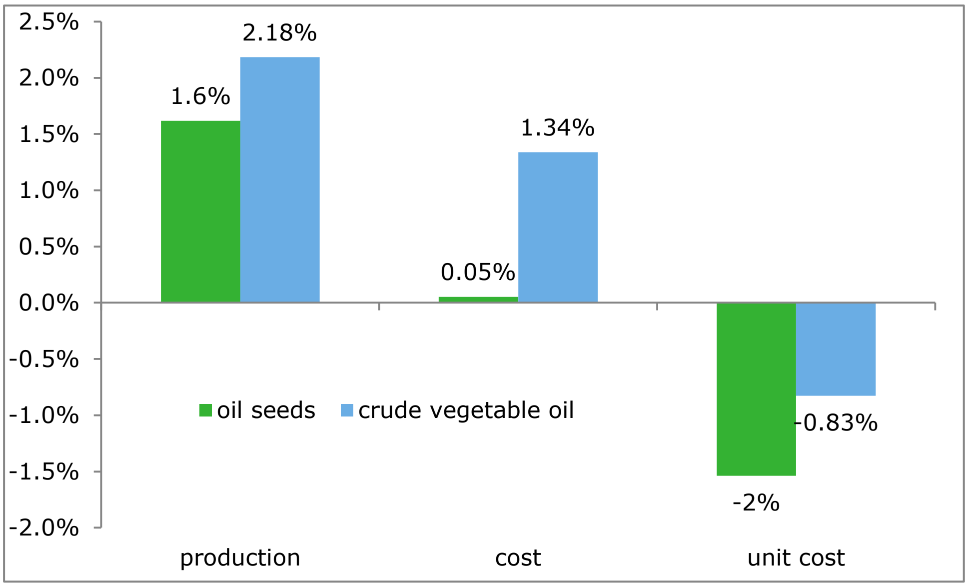

Figure 13 *Impacts on producers in Ghana in 2025 - oilseeds and vegetable oil loss scenario (percentage difference from the baseline).*

4.4.2 Impact on consumers

From the point of view of consumers only the oilseeds and refined (not crude) vegetable oil matter, while for production purposes, reduction in oilseed loss matters for production of crude vegetable oils. As a result, note that the second commodity in the graphs are different. And while price of crude vegetable oil produced falls by 2%, not much of it is transmitted to the vegetable oil consumed. The reason for this low transmission is that crude vegetable oil accounts for only 9% of costs of production of refined vegetable oil that is consumed by households. A reduction in price of oilseeds does boost the demand for oilseeds consumed in Ghana by about 0.2%. With this modest change in consumption, we do not see a large change in calorie intake. As for household income from unskilled labour, we see a modest increase of about 0.1%, which is in line with the increase in labour demand by the oilseeds sector (0.13%).

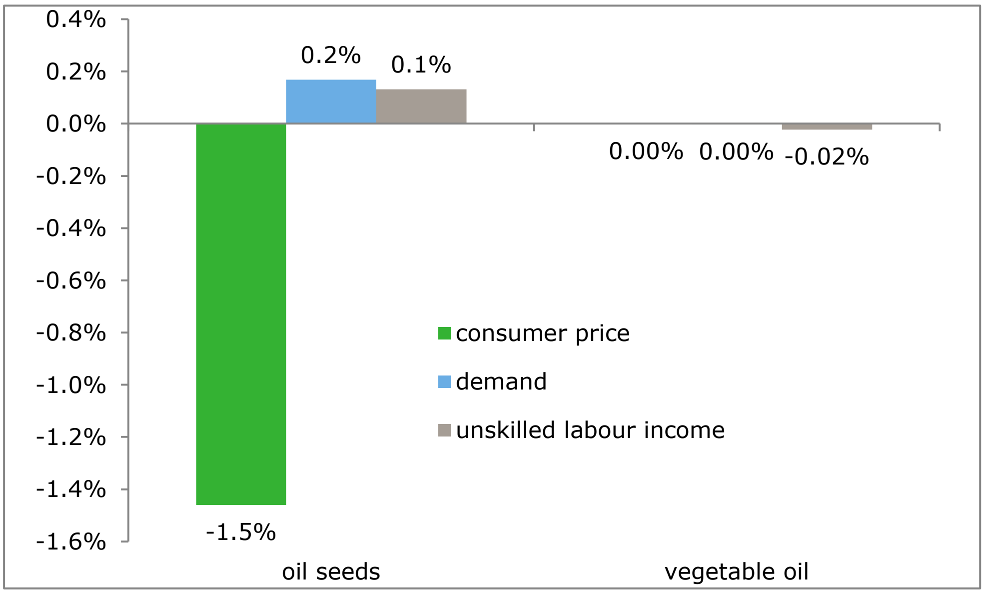

Figure 14 *Impacts on consumers in Ghana in 2025 - oilseeds and vegetable oil loss scenario (percentage difference from the baseline)*

4.5 Tackling food loss in the Ghanaian fish chain

Reduction in fish loss results in increased production (0.7%) but lower revenues (6%). Consumers pay a 7% lower price for fish bought in Ghana and Ghanaians demand 1.5% more fish. The households that work as labourers in fisheries see their incomes fall by 3%.

Reducing production losses in the fish supply chain involves reducing fish loss at the production stage, for example by using better fishing equipment that does not disfigure fish while being caught, processing fish into 'other processed food' in a way in which less of the fish caught is lost while being processed and finally improving distribution efficiency so less is lost in the retail market and restaurants.

4.5.1 Impacts on fish producers

With reduction in losses in fish supply chain, we see a modest increase in output of fish (0.7%) and a much larger reduction in total as well as per unit costs, by 6 and 7% respectively. Again because of perfect competition, a reduction in total costs also means a reduction in revenues. With all inputs becoming more efficient in fish production and only a modest increase in fish output, the demand for unskilled labour in this sector sees a 3% reduction.
Fish as an input accounts for only 2% of the cost of 'other processed food' production. So we do not see very large changes in this food category. As seen from Figure 15 below, production of 'other processed food' increases by 0.9%, total costs are not much affected while the unit costs and market

price falls by 1%. A closer look at input use shows that cost of fish and demand of fish in the sector both fall by 29 and 24% respectively, while demand for other inputs like that for unskilled labour increases.

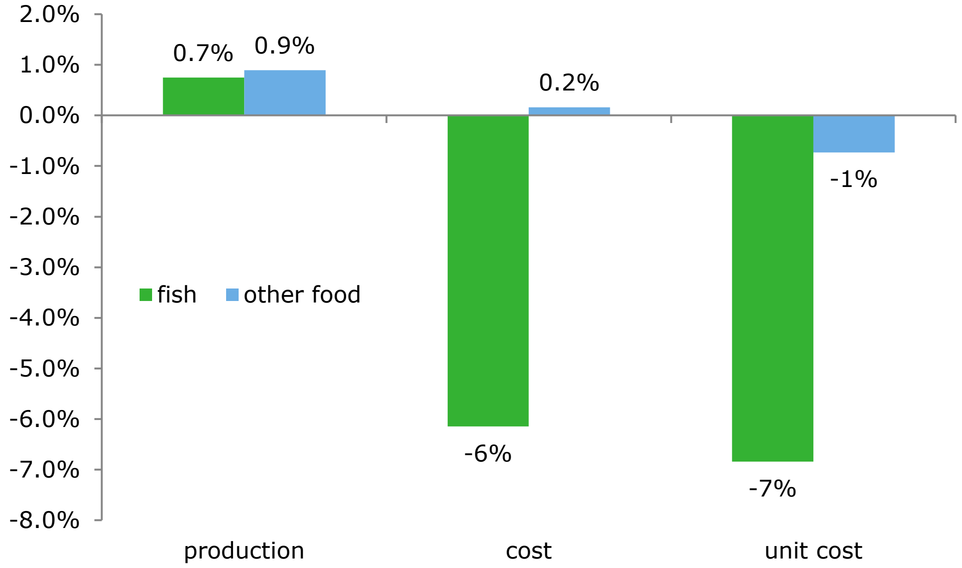

Figure 15 *Impacts on producers in Ghana in 2025 - fish loss scenario (percentage difference from the baseline).*

4.5.2 Impacts on consumers

A 7% reduction in the price of fish, makes consumers in Ghana demand more fish. As seen in Figure 16, the demand for fish in Ghana increases by 1.5%. Price reduction (0.6%) and associated increase in demand (0.02%) for 'other processed food' is much less in comparison, which is not surprising given that fish accounts for only 2% of cost of production of 'other processed food'. In other words, fish is not a major input into 'other processed food' category. Again with very small changes in consumption, we do not see major changes in calorie intake.

From section 4.5.1, we know that demand for unskilled labour in fish production falls while the demand for unskilled labour in 'other processed food' sector increases. As a result, we see that income of unskilled labour earned in the fish sector falls by about 3% but income earned in the 'other processed food' sector increases by about 1%.

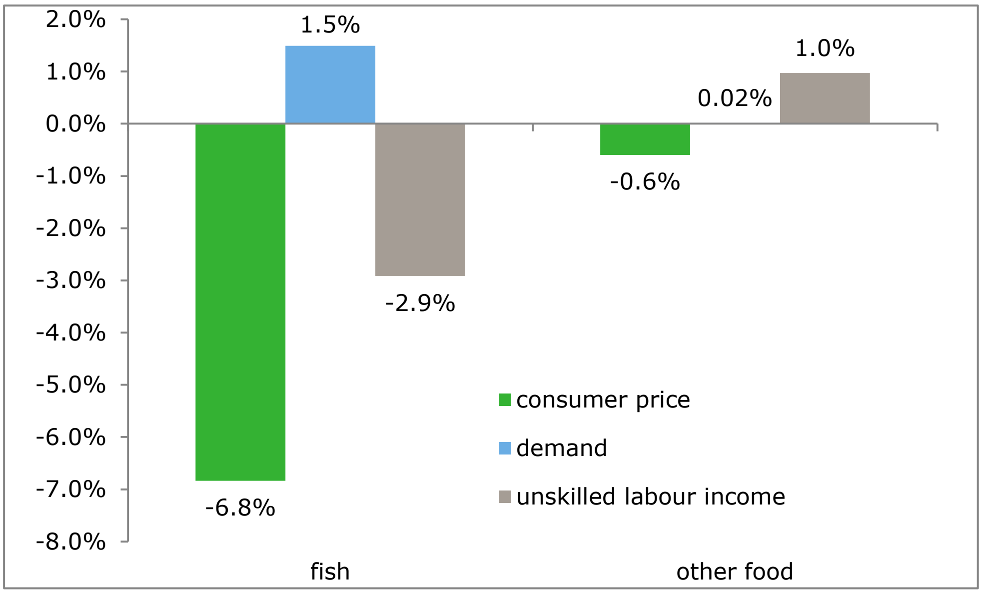

Figure 16 *Impacts on consumers in Ghana in 2025 - fish loss scenario (percentage difference from the baseline).*

4.6 Overall scenario: tackling food loss in Ghanaian crops and fish

When food loss in reduced by 50% in all five commodity chains - rice, fruits-vegetables-nuts, maize, oilseeds and fish - we see an increase in Ghanaian GDP by 0.8%. The trade balance (exports - imports) for these commodities also improves for Ghana.
Welfare results show that the gains from a 50% food loss reduction in these commodities by the year 2025, are equivalent to an additional USD19 per capita per year.

In this final scenario we look at the aggregate impacts if Ghana reduces its food loss by 50% for all of the five commodity categories.

4.6.1 Impacts on producers

When 50% food loss reduction is undertaken in all five commodity groups, we see similar changes in producer costs, prices and production as we did in the individual commodity loss reduction scenarios. Some minor changes are seen for primary commodities because of inter-sectoral interactions in the economy, for example all commodities are competing for the resources available in terms of land and labour. For food commodities like 'other processed food' the changes are slightly more noticeable because in this scenario all three commodities that are used as inputs into ‘other processed food’ production - vegetables and fruits, fish, and maize - are seeing a loss reduction. Figure 17 below shows the impacts on all commodities directly influenced by reducing food loss. It also helps us make a comparison across commodities. Processed rice sees the largest percentage increase in production, followed by paddy, fruits and vegetables and ‘other processed food’. Note that we argued before that Ghana is a net exporter of primary products while being a net importer of processed food. In the light of this fact the results suggest an improvement in Ghana's trade position, which we discuss in the section on macroeconomic impacts below. As one should expect, unit cost of production for all primary and processed commodities falls when food loss is reduced.

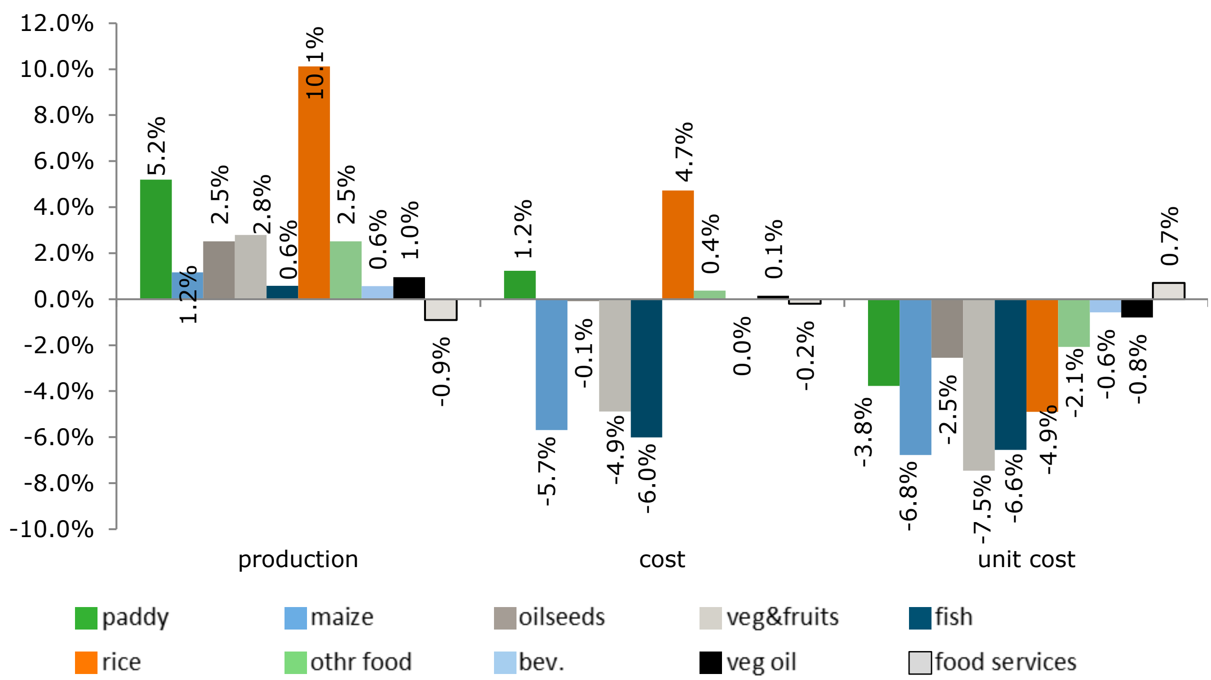

Figure 17 *Impacts on producers in Ghana in 2025 - all commodities loss scenario (percentage difference from the baseline)*

4.6.2 Impacts on consumers

As expected a food loss reduction in Ghana leads to a fall in commodity prices for consumers. The largest reduction is seen in the price of vegetables, fruits and nuts, a commodity which has the largest share in consumption expenditure. This is also the commodity that sees the largest increase in consumption demand. In terms of income from unskilled labour, most of the increase comes from processed rice. Despite the sectoral differences, as a total we see a 2% reduction in income from unskilled labour.

Note that in the supply chain and especially so in the developing countries, agricultural production is usually concentrated in rural areas and processing activities usually take place in urban areas and are not a part of agriculture. In this light we can approximate the impact of food loss reduction on rural and urban unskilled labour by means of unskilled wages in agricultural and non-agricultural sector. Our model results show that unskilled labour employed in agricultural activities sees a 1.3% drop in wages, while unskilled labour employed in the non-agriculture activities sees a moderate increase in wages (0.86%). This is not surprising, as we can see from Figure 18 that unskilled labour income is falling for labour employed in production of most of primary commodities (for maize by 5.5%, for fruits vegetables and nuts by 4.3% and for fish by 2.5%). Similarly it can be seen in Figure 18 that income earned from processing sectors sees in increase (for rice, 'other processed food', beverages and vegetable oil).

We claimed that changes in the calorie intake for the individual were too small to report. When we aggregate the calorie intake from changed consumption of all the food groups involved, we notice an increase of 29 calories per capita per day in Ghana in the year 2025. By the year 2050, this increase is actually 69 calories. This is still not a large increase when compared to total per capita per day calorie consumption - 3,232Kcal in 2025 and 3,607Kcal in 2050.

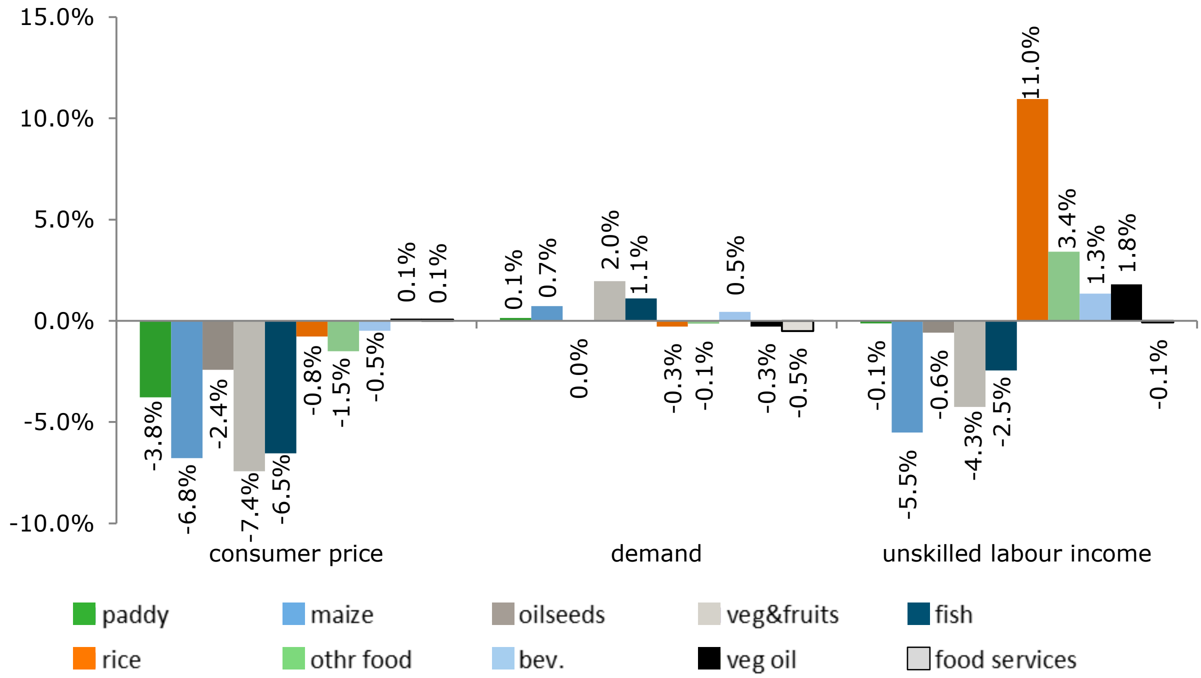

Figure 18 *Impacts on consumers in Ghana in 2025 - all commodities loss scenario (percentage difference from the baseline).*

4.6.3 Macroeconomic impacts

While we refrained before from reporting macro-economic impacts of reducing food loss at the individual food category level, these are important considerations that deserve a thought in assessing the impact of food loss reduction in the economy. Specifically we look at impacts on economic growth (GDP), the trade balance, and economy-wide welfare.

When food loss is reduced in all five food categories by 50%, GDP in Ghana increases by 0.8%. We do not look at impact on GDP for each individual case as each food category by itself accounts for a very small part of the economy and therefore GDP impact would be negligible. Also, the loss reduction is only 50%, so some shocks are very small.

Looking at the trade balance, we see that in 2014 Ghana starts out as a net exporter of primary commodities - paddy, maize, oilseeds, vegetables, fruits and nuts, and fish; and a net importer of the associated processed commodities (vegetable oil, ‘other processed food’, processed rice, beverages).

With reduction in food loss in all five commodity groups, the current account balance for paddy rice and processed rice improves by 39% (net exports of paddy increase from USD 51m to USD 71m) and 3% (net imports of processed rice fall from USD 247m to USD 240m) respectively. While Ghana remains a net exporter of paddy rice and a net importer of processed rice, its position for both improves as it becomes more competitive; its net exports of paddy increase while its net imports of processed rice fall. The next significant improvement is seen for fruits and vegetables and fish, as both see a 23% increase in their net exports coming from a reduction in imports and expansion in Ghanaian exports of the two commodity groups. Ghana sees its trade balance for 'other processed food' category also improve by 20% as the increase in exports outweighs the reduction in imports of ‘other processed food’ category, though Ghana still remains a net importer (net imports under the ‘other processed food’ category fall from USD 198m to USD 148m). Net exports of maize and oilseeds increase by 15 and 8% respectively and the trade balance of associated processed commodities all change under 1%.

For the economy as a whole the current account balance becomes worse with net exports falling by 2.7%, this comes from an increase in imports (1.3%) while value of total exports falls by 1%. While the trade balance for Ghana in agricultural commodities (as stated above) improves its imports of manufacturing and services sectors increase more than its exports, as the Ghanaian economy grows.

Finally in terms of welfare, Ghana experiences an annual gain of USD 619m (USD 19 per capita), in 2025 from reducing food loss in the five food categories, which represents 0.6% of GDP in Ghana in the year 2025. This figure can be interpreted as an upper bound on the cost that could be used to foot the bill for undertaking food loss reductions in Ghana. If reducing food losses in Ghana costs more than this amount then, we can say that it is not economical to reduce food loss, unless there other impacts on society result that make this investment worthwhile. For example, improved road infrastructure would reduce food loss by improving access to markets but it can also improve access to hospitals for poor in the remote areas.

4.6.4 Long-term macro-economic outlook

The GDP numbers fall further by 2050 (to 0.02%) as the economy grows, with services and manufacturing becoming more important and agriculture as a sector loses its value share in the economy from 14 to 5%.

The Trade balance for Ghana by 2050 increases to 111% for paddy and 45% for fruits and vegetables. All primary products see an improvement in net exports of over 20% and the gain for processed products though not as large as for primary products, is positive.

The welfare gain by the year 2050 is USD 1,500m per year and represents about 0.4% of Ghanaian GDP. In per capita terms, every person in Ghana in 2050 gains an equivalent of USD 32 per year.

5 Conclusions

Broadly speaking the impacts of reducing food loss in Ghana by 50% by 2025, leads to a fall in unit costs of production for all food groups and an increase in production. These changes contribute to increased sales, potentially leading to higher revenues. However, because market prices of food commodities received by producers fall, producers do not necessarily always increase their revenues through increased sales. While paddy and rice producers definitely see an increase in revenues, for most other producers the reduction in market price for their product is more than the increased output and they lose revenues. Consumers always gain in terms of reduced food prices and increased consumption. However, their incomes earned by supplying unskilled labour to the food producing sectors may fall or rise. As we explained earlier, for the economy as a whole we see unskilled wages in the primary agriculture activities - which are likely to be concentrated in the rural areas in Ghana - fall and unskilled wages in agricultural processing sector – possibly concentrated in the urban areas - increase.

For the economy as a whole Ghana sees a modest increase in GDP (0.8%) when food loss is reduced by 50%, and the welfare gains are equivalent of USD 19 per capita in 2025, increasing to USD 32 per capita per year by the year 2050, despite increasing population. Therefore, Ghana should undertake 50% food loss reductions measures, if it can use policies/measures that cost tax payers anything less than USD619m. Ghana also sees an increase in its trade balance for the agricultural sector, however it is not enough to produce an improvement in trade balance for the economy as a whole.

It is often assumed that all food loss is bad, but it may be argued that some amount of food loss is economically efficient; for example if it costs more to reduce the loss than the value it saves, it is not economically desirable to reduce that loss. As more and better field data becomes available, these estimates of costs and benefits of food loss can be improved. A second note is that our model does not explicitly model food loss as a function of underlying causes. To link underlying causes would require a lot more details in terms of commodities involved and reasons of food loss in Ghana. Detailed field studies may help achieve this last goal. Information on reasons of food loss reduction would also make it possible to evaluate different measures that Ghana could undertake to reduce food loss and help policy makers choose the best possible strategy available. Note that food loss reduction can also come about as an unintended consequence of improved infrastructure (transport network) by improving producers access to markets. This is because infrastructure as a basic facility works towards several desirable goals (as stated in section 4.6.3)

Finally, it would be desirable to look at impacts of food loss reduction at the household level, as our results suggest that how consumers and households earn their income plays an important role in what will happen to their income and earnings. Work is being undertaken to include these details in the model.

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LEI Wageningen UR
P.O. Box 29703
2502 LS The Hague
The Netherlands
T +31 (0)70 335 83 30
E publicatie.lei@wur.nl
www.wageningenUR.nl/en/lei

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LEI Wageningen UR
Postbus 29703
2502 LS Den Haag
E publicatie.lei@wur.nl
www.wageningenUR.nl/lei

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