INCREASING RELIABLE, SCIENTIFIC DATA AND INFORMATION ON FOOD LOSSES AND WASTE IN SOUTH AFRICA

Technical report

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EXECUTIVE SUMMARY

Food loss and waste is an issue of global concern based on the estimate that one third of all food produced for human consumption is lost or wasted (Gustavsson *et al*., 2011). South Africa has committed to achieving the Sustainable Development Goals for 2030, which includes domestication of Goal 12.3 and measuring progress made towards food loss and waste reduction. Previous estimates of food losses and waste in South Africa (Oelofse and Nahman, 2013) applied the methodology used in the global study but specifically using the assumptions for sub-Saharan Africa (Gustavvson *et al*., 2011).

This project therefore has three objectives as follows:

1. To critically analyse the methodology used in the global study and in previous estimates of food losses and waste in South Africa;
2. To critically analyse the assumptions used in the global study and in previous estimates of food losses and waste in South Africa;
3. To update the food loss and waste estimate for South Africa.

The findings suggest that the broad methodology used in previous estimates of food losses and waste in South Africa (Oelofse and Nahman, 2013) are appropriate, but do not account for non-food by-products produced from food losses and waste. Identified weaknesses/flaws in the assumptions of the previous South Africa study mainly relate to:

- Choice of commodity used as a proxy;
- Scale and level of sophistication available at each stage of the value chain;
- Availability of cooling systems during storage and transport;
- Market and marketing systems; and
- Consumer behaviour.

The assumptions for estimating food loss and waste as a percentage at each stage of the food value chain are updated and applied. The results of this new, updated study estimate pre-Covid-19 food losses and waste for South Africa at 10.3 million tonnes per annum based on the five year average (2014-2018) food supply. This estimate is in the same order of magnitude as the previous 2013 estimates, but the distribution of the losses and waste across of the value chain have changed. Most losses and waste (49%) occur at the processing and packaging stage in the value chain, whereas food waste at the consumption stage (18%) is more than three times higher than previous estimates for South Africa.

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1 Introduction

This report is submitted to the Department of Science and Innovation, as a deliverable on a targeted research grant project on food waste in South Africa. The project builds on the CSIR's research on food waste undertaken during 2010-2015, which is currently the only national quantitative and economic research on food waste for South Africa.

1.1 Background

It is estimated that one third of all food produced in the world, intended for human consumption, is lost or wasted (Gustavsson *et al*., 2011). These losses and waste are the result of inefficiencies along the food value chain; and give rise to economic, social and environmental impacts amounting to US$940 billion (Hanson and Mitchell, 2017). Food losses and waste in South Africa were estimated to be in the order of 9.04 million tonnes per annum (the average for 2007 to 2009) (excluding food imports and exports), or 31.4% of the average annual agricultural production for the country (28.79 million tonnes per annum) (Oelofse and Nahman, 2013). If imports and exports are added, the total food waste estimate increases to 10.2 million tonnes per annum, at a cost to society of R61.5 billion per annum (2.1% of South Africa's GDP) (Nahman and de Lange, 2013).

The first estimate by Oelofse and Nahman (2013) was undertaken to get a perspective on South Africa's contribution to the global food waste challenge. The early South African estimates used the assumptions in the Global Food Waste Assessment for sub-Saharan Africa (Gustavsson *et al*., 2011). The (then) Department of Science and Technology's (DST) Industry-meets-Science workshop on food losses and waste held in Johannesburg on 15 February 2017, confirmed that food loss and waste is an issue of local and global concern. Furthermore, South Africa has committed to achieving the United Nations Sustainable Development Goals (SDGs) for 2030, which includes domesticating SDG 12.3: "*By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses*". In order to move South Africa towards realising this Goal, the "*immediate priority lies in better understanding the nature, magnitude and drivers of food waste, through the generation of reliable scientific data and evidence – across the food supply chain and across different food types*" (DST, 2017).

A report explaining the methodology used for the global assessment, which outlined the details of the assumptions used for sub-Saharan Africa, was published in 2013 (Gustavsson *et al*., 2013). The CSIR has for some time questioned whether these assumptions for sub-Saharan Africa are in fact appropriate for South African food waste estimates. Oelofse *et al*. (2020) highlight that South Africa is not a typical sub-Saharan Africa country, specifically when considering the central role that modern food supply chains play in South Africa. Specific issues to consider are the central role of large commercial farming, "*four South African food giants*" dominate food processing (Oelofse *et al*., 2020), and the highly concentrated food retail market with seven companies accounting for 80% of all retail sales (Ntloedibe, 2019).

An updated food waste estimate for South Africa is urgently needed to better inform the setting of targets for food waste reduction in line with SDG 12.3.

1.2 Aim of the study

The aim of this study is to support South Africa’s domestication of SDG 12.3 by generating reliable scientific data and evidence, across the food supply chain and across different food types, appropriate for South Africa.

1.3 Scope of the project

The scope of this project was as follows:

- Highlight the (i) flaws/weaknesses in the assumptions and (ii) gaps in data used in the 2007-2012 food waste research (which was the best available data and methodology at the time)
- Refine the methodology for food waste estimates in South Africa through the following key work streams:
  - Review all relevant available documents, reports, theses and scientific literature on food waste in South Africa and Africa; and
  - Collect new, primary data to fill identified data gaps or address weak assumptions, throughout the South African supply chain(s)
- Undertake updated calculations of the magnitude (quantity) of food waste in South Africa based on the refined methodology, and using more recent data (e.g. Department of Agriculture Forestry and Fisheries (DAFF) and Associations, production data, etc.).

2 Approach and methodology

2.1 Critical analysis of the assumptions used in 2010-2015 estimates

Following the publication of the first South African estimate of food waste by Oelofse and Nahman (2013), a report detailing the assumptions used in the 2010 Global Assessment of food waste (Gustavsson *et al*., 2011) (on which the South African estimate was based) was published (Gustavsson *et al*., 2013).

The first task in this study, was to undertake a detailed literature review of the validity of Gustavsson’s sub-Saharan Africa assumptions in the South African context. The literature review interrogated the following aspects as contained in the assumptions:

- Are the commodities used in the assumptions relevant to the South African context?
- Are the production systems, harvesting methods, processing technologies, and retail systems implied by the assumptions appropriate for South Africa?
- Are the scale of operations implied in the assumption relevant for the commodities in the South African context?

2.2 Critical analysis of the methodology used to calculate food waste in South Africa

The methodology used to calculate the food waste estimates for South Africa was critically analysed against the backdrop of local South African conditions and primary data collected during this project, complemented by data from literature reported between 2003 and 2020 (inclusive). The literature review has been captured as a separate review paper for publication in a peer reviewed scientific journal.

Primary data collection included structured and semi-structured interviews, and self-administered questionnaires with stakeholders in each stage of the value chain, but excluding consumers. The interviews and questionnaires solicited both quantitative and qualitative data on food losses and waste throughout the value chain, but also provided good insights into the South African food system as compared to the rest of sub-Saharan Africa. Data at the consumption stage of the supply chain were sourced from available documented scientific studies that emerged from the literature review.

2.3 Food balance data and food loss and waste calculations for South Africa

It is important to note that not all agricultural production in a country enters the food supply chain. Significant portions are allocated to animal feed, seed production, and other non-food applications (Annexure A). Therefore, it is important to have an indication of the food balances across the value chain to inform the calculations of the food losses and waste at each stage of the value chain.

Data on actual quantities (tonnes) of food supply for each commodity entering the value chain in South Africa were sourced from the Food Balance Sheets published by the Statistics division of the Food and Agriculture Organisation (FAOSTAT, 2021). The commodities were grouped into the same commodity groups as used in earlier studies (Gustavsson *et al*., 2011; Oelofse and Nahman, 2013; Nahman and de Lange, 2013) by simply adding the food supply data for the individual commodities belonging to each commodity group. This was a simple calculation, as it was relatively easy to match the commodities to the different commodity groups. This approach was followed to ensure that the new food waste estimates for South Africa could be compared to the previous estimates.

To compensate for year-on-year variations in production, we have calculated the average food supply per commodity group over a 5 years period (2014-2018; the latest-available data) and the results of the calculations are presented in Table 1. The average annual food supply figure was used as the starting point for the food loss and waste calculations. Imports and exports are already factored into the food supply figure obtained from Food Balance Sheets (FAOSAT, 2021) (Refer to Annexure A) and was therefore not addressed at the distribution stage as suggested by Nahman and de Lange (2013). The reason for this approach is to keep the calculations as simple as possible for duplication by other researchers, using standard data from publically available sources.

The average losses during transport and storage in South Africa are also indicated on the Food Balance Sheets (FAOSTAT, 2021) (refer to Appendix A). Primary data collection confirmed that these numbers are indeed appropriate for use in the local context. The average percentage loss per year is calculated by dividing the average loss over the 5-year period (Table 2) by the average supply over the 5-year period (Table 1) for each commodity group.

Table 1: Average annual food supply in South Africa (Calculated from FAOSTAT, 2021).

	Annual food supply for South Africa ('000 t)					
	2014	**2015**	**2016**	**2017**	**2018**	**Average**
Cereals	10 194.00	9 858.00	10 319.00	10 523.00	10 434.00	10 265.60
Roots and tubers	1 778.00	1 789.00	1 808.00	1 841.00	1 874.00	1 818.00
Oilseed and pulses	273.00	415.00	228.00	301.00	304.00	304.20
Fruit and vegetables	3 955.00	4 075.00	3 484.00	3 536.00	3 602.00	3 730.40
Meat	3 467.00	3 508.00	3 642.00	3 563.00	3 704.00	3 576.80
Fish and seafood	389.39	361.67	347.14	366.99	366.99	366.44
Milk	2 564.00	2 683.00	2 700.00	2 785.00	2 880.00	2 722.40
Total	**22 620.39**	**22 689.67**	**22 518.14**	**22 915.99**	**23 164.99**	**22 783.84**

Table 2: Average annual losses during transport and storage in South Africa (calculated from FAOSTAT, 2021)

	Losses during transport and storage ('000 t)						
	2014	**2015**	**2016**	**2017**	**2018**	**Average**	**Avg. loss %**
Cereals	601	433	380	867	672	590.6	5.8
Roots and tubers	170	188	163	186	187	178.8	9.8
Oilseed and pulses	117	107	101	127	132	116.8	38.4
Fruit and vegetables	674	709	650	690	688	682.2	18.3
Meat	0	0	0	0	0	0	0
Fish and seafood	0	0	0	0	0	0	0
Milk	0	0	0	0	0	0	0

The quantity of food losses and waste at each stage of the value chain was calculated by multiplying the quantity of food entering each stage of the food value chain for each commodity group (as per the FAO data) (Table 1) by the percentage that is lost or wasted (Table 4). For example, the quantity of food entering the post-harvest stage of the value chain was calculated as the quantity of food entering the agricultural production stage, less food waste at the agricultural stage, and so on for each stage in the value chain. Fruit and vegetables entering the processing stage of the value chain is the only exception to this rule in our calculations. Oelofse and Muswema (2018) determined that 43.5% of all fruit and vegetables produced in one year are send for processing. Therefore, only 43.5% of the output from the post-harvest handling and storage stage (input less the calculated losses and waste) are assumed to enter the processing stage of the value chain. The remaining 56.5% (1 556 990 tonnes) not processed, were again added to the input entering the distribution stage of the value chain. This was done to compensate for the fact that the 32% assumed losses (calculated from Oelofse and Muswema, 2018) during processing and packaging are based on processing losses only. The resulting quantities, and percentage losses at each stage of the value chain, are presented in Table 5.

3 Results and Discussion

3.1 Critical analysis of the assumptions used in 2010-2015 estimates

The detailed methodology used in the 2011 global study was published in 2013 (Gustavsson *et al*., 2013), shortly after the publication of the South African estimate. The disclosure of the detailed methodology (Gustavsson *et al*., 2013) revealed certain limitations in assumptions for sub-Saharan Africa, which do not necessarily ring true for the South African specific context. Sub-Saharan Africa is a developing region while South Africa is one of the most industrialised countries in Africa (Bakari, 2017), with modern food supply chains (Crush and Frayne, 2011). These unique South African features are a-typical of most countries in sub-Saharan Africa where food value chains are more traditional with lower levels of sophistication (Maertens *et al*., 2012). Oelofse and Nahman (2013) emphasised the preliminary nature of their estimates and cautioned that these were subject to verification through ongoing research. The results from the critical analysis per assumption across the value chain are summarised in Table 3.

Based on the analysis and recommendations on more appropriate assumptions in the South African context, revised proportions (by mass) of food entering each stage of the value chain that is lost or wasted, is proposed. The revised proportion losses are presented in Table 4 and the rationale for each assumption is provided in the footnote linked to each percentage.

The updated percentages are aligned with South African conditions and informed by local studies and data. It should be noted that the new proposed percentage losses is an improvement on the assumptions used for sub-Saharan Africa, but shortcomings remain in that some of the new assumptions are based on small-scale studies undertaken in South Africa, which are not necessarily representative of all South African conditions.

Lastly, the methodology estimates losses and waste incurred throughout the food supply chain, but does not account for the diversion of food losses and waste to other non-food related by-products. Primary data suggest that on-farm losses and waste are typically used as animal feed, ploughed back into the fields for soil enrichment, or used in the production of composting. While surplus food is donated to charities. Similarly, food losses incurred during food processing are diverted to other non-food products such as animal feed or other industrial uses including extraction of oils, enzymes and other components. As such, the methodology account for food losses and waste from a food security perspective, but not from an economic or waste management perspective.

Table 3: Evaluation of the assumptions used in the 2013 food waste estimate for South Africa

	Commodity	Assumption used in the 2013 estimate (Gustavsson et al., 2013)	Nature of the weakness/flaw	More appropriate assumption for South Africa
Agricultural production	Cereals	Harvest losses for cereal is based on the Harvest losses for rice in China and Sierra Leone (6%)	South Africa does not produce rice (DAFF, 2019). Cereal crops produced in South Africa are maize, wheat, sorghum and barley. Maize is the most important grain crop being the staple food of the majority of the South African population (DAFF, 2019). Using rice as a proxy for cereals in the South African context is therefore inappropriate.	The South African grain sector faces undue pressure to produce maize profitably at export parity prices. Combine harvesters are widely used by grain farmers in South Africa reducing harvest losses to below 1% (Rǜsch, 2001: 2).
	Roots and Tubers	Typical harvest losses in Africa, cassava (14%)	Cassava is grown as a subsistence crop in South Africa (Alleman *et al.,* 2004). Using cassava as a proxy for roots and tubers in the South African context is therefore inappropriate.	Roughly, 80% of potatoes are produced on large commercial farms. Mechanical harvesting result in <1% harvest losses in field, but contributes to increased losses being realised during sorting and packaging (primary data collection). Potato crop losses for SA are estimated at 10-45% as a result of weeds, pests and diseases (Oerke *et al*., 1999) Since 80% of the production is on large commercial farms, the assumption is 10% (based on the lower value from Oerke *et al*.,1999).
	Oilseeds and Pulses	Typical harvest losses in developing countries, for coconut and groundnut (12%)	South Africa is not a producer of coconut, and groundnuts only contribute a small portion of the local oilseed and pulses production. Coconut and groundnuts are therefore inappropriate crops to use as proxy in the South African context.	Oilseeds produced in South Africa include sunflower seed, soya beans, groundnuts and canola (Protein Research Foundation, 2017; DAFF, 2017; DAFF, 2019) Combine harvesters are widely used by sunflower and canola farmers in South Africa reducing harvest losses to below 1% (Rǜsch, 2001: 2).
	Fruit and Vegetables	Typical harvest losses in India (Okra, Tomato, Mango); Bananas in Costa Rica (10%)	The main vegetable crops produced in South Africa are tomatoes, onions, cabbages, pumpkins and carrots; whereas fruit crops include deciduous fruit (e.g. apples, pears and table grapes, etc.), subtropical fruit (e.g. avocados, bananas, pineapples, mangoes, etc.) and citrus (e.g. oranges, grapefruit, lemons, naartjes, etc.) (DAFF, 2018; DAFF, 2019). Limiting the assumption to the crops produced in India is a weakness in the South African context.	It is necessary to consider the wider range of commodities produced in South Africa to come up with a realistic assumption. The average estimated harvest losses for carrots, lettuce, cabbage, tomatoes, peppers, citrus, bananas, avocados, table grapes and pineapples by large scale farmers in SA is 9%. (primary data)
	Meat	Calf mortality rates in Mali and Pakistan, pig mortality in the	Diseases such as foot and mouth disease (FMD) are well controlled in South Africa with FMD free zones.	Chicken mortality stood at 4.1% in 2017 (SAPA Poultry, 2017).

	Commodity	Assumption used in the 2013 estimate (Gustavsson et al., 2013)	Nature of the weakness/flaw	More appropriate assumption for South Africa
		Himalayas and chicken mortality in Sudan, Lamb mortality in Ethiopia. The 19% was a weighted average. (19%)	FMD is widespread in Pakistan (Jamal *et al*., 2010) and West Africa, including Mali. Using data from these countries are therefore inappropriate in the South African context.	The weighted average losses for red meat is 7.87% (refer to Appendix B) The weighted average loss of all meat is therefore 6.03%
	Fish and seafood	This assumption is based on the Kelleher Fishery categories (Kelleher, 2005). Tuna purse seine, Tuna and HMS long-line, Gillnet, Tuna pole and Line, Hand-line and Multi-gear and multispecies (5.7%)	Harvested species in South Africa are Patagonian Tooth Fish, Hake (trawling and longlining), deepwater lobster, in-shore line fish, prawn trawling (KZN), Tuna (pole), Demersal Shark, West Coast Lobster (off shore traps; inshore hoop nets), oyster, mussels, abalone, kelp and seaweeds (Branch and Clark, 2006) Using Tuna as proxy for South Africa is inappropriate due to the difference in fishing methods to harvest different species.	A more accurate assumption for South Africa would be based on Hake, Sardine and Tuna catches (SADSTIA, 2021). The wastage is estimated from catch until landing Applying a weighted average based on the catch the estimated loss is 0.75%. (Refer to Annexure C).
	Milk	Milk losses in Uganda (6%)	Uganda focus on extensive systems of 30 cows per farm. South Africa focus on intensive farming systems of on average 354 cows per farm (Milk SA, 2018). The milking systems in South Africa are highly mechanised due to the size of the herds. Using Uganda milk losses as a proxy for South Africa is therefore inappropriate.	Large commercial farmers use milking machines. Milking machines are closed systems resulting in little milk spillage, very low risk of environmental contamination, and guaranteed cleanliness provided the equipment is thoroughly cleaned (losses are therefore estimated at <1%). (https://medilinkvet.wordpress.com/2015/11/21/the-abcd-of-using-milking-machines/)

	Commodity	Assumption used in the 2013 estimate (Gustavsson et al., 2013)	Nature of the weakness/Flaw	More appropriate assumption for South Africa
Postharvest handling and storage	Cereals	Losses during transport, handling and storage of cereals between farm and distribution based on FAOSTAT statistics (8%)	South African data is available and reported by DAFF. The weakness here is using on FAOSTAT data whereas local South African data is available.	Losses during transport, handling and storage of cereals between farm and distribution based on FAOSTAT statistics for South Africa (5.8%) (Table 2).
	Roots and Tubers	Losses during transport, handling and storage of root and tubers	South African data is available and reported by DAFF. The weakness here is using on FAOSTAT data whereas local South African data is available.	Losses during transport, handling and storage of cereals between farm and distribution based on FAOSTAT statistics for South Africa (9.8%) (Table 2).

Commodity	Assumption used in the 2013 estimate (Gustavsson et al., 2013)	Nature of the weakness/Flaw	More appropriate assumption for South Africa
	between farm and distribution based on FAOSTAT statistics (18%)		
Oilseeds and Pulses	Losses during transport, handling and storage of oilseeds and pulses between farm and distribution based on FAOSTAT statistics (8%)	South African data is available and reported by DAFF. The weakness here is using on FAOSTAT data whereas local South African data is available.	Losses during transport, handling and storage of cereals between farm and distribution based on FAOSTAT statistics for South Africa (38.4%) (Table 2).
Fruit and Vegetables	Losses during transport, handling and storage of fruit an vegetables between farm and distribution based on FAOSTAT statistics (9%)	South African data is available and reported by DAFF. The weakness here is using on FAOSTAT data whereas local South African data is available.	Primary data collected during this project for a limited number of commodities suggest post-harvest losses of between <1-21%. Losses during transport, handling and storage of cereals between farm and distribution based on FAOSTAT statistics for South Africa (18.3%) (Table 2).
Meat	Mortality rate during transport to slaughter. Cattle in Nigeria, Pigs in Chile, birds in US, broilers in Italy. (various sources) (0.7%)	South African data is available and reported by DAFF. The weakness here is using on FAOSTAT data whereas local South African data is available.	The reported number for South Africa is between 6-8% (DAFF, 2015:3) The feedlot industry reports mortality for the total production cycle for cattle as 2.56% (ARC, 2021). The same mortality is assumed for sheep and goats (ARC, 2021). The 6-8% as reported by DAFF, may apply to poultry only. Using the weighted average of the midpoint for poultry and 2.56% for all red meat, the assumed percentage loss for meat is 5.22%.
Fish and seafood	Refrigerated transport is often lacking or inadequate, preparation and freezing is mostly done on land, and a great proportion of fisheries are small scale. Based on small-scale fishing in developing countries (6%)	Small-scale fishing operations are not the norm in South Africa. The commercial fishing sector in South Africa include highly industrialised deep-sea fisheries and more traditional near-shore fisheries (McCord and Zweig, 2011). It is therefore inappropriate to use small-scale fishing operations as the basis for an assumption. Furthermore, South African data is available and reported by DAFF. The weakness here is using FAOSTAT data whereas local South African data is available.	Discards (damaged, spoilt or too small) are 2-3% for hake, 0.5% for sardines and 0% for Tuna (large fish that are immediately blast frozen) (SADSTIA, 2021). The weighted average loss is 0.44%.

	Commodity	Assumption used in the 2013 estimate (Gustavsson et al., 2013)	Nature of the weakness/Flaw	More appropriate assumption for South Africa
	Milk	Milk Losses in Uganda (11%) spillage during transport	South African data is available and reported by DAFF. The weakness here is using on FAOSTAT data whereas local South African data is available.	In South Africa the bulk of milk is transported in bulk milk collection tankers and only a small portion is transported in milk cans. Transport in tanker trucks limits spillage during transport. The reported number for South Africa is between 8-16% (DSA, 2015; DAFF, 2015:3)

	Commodity	Assumption used in the 2013 estimate (Gustavsson et al., 2013)	Nature of the weakness/flaw	More appropriate assumption
Processing and packaging	Cereals	3.5% is based on the lower end of reported losses during small scale milling and small scale baking operations	Large-scale mills produce wheat flower and maize meal in South Africa. It is therefore inappropriate to use small-scale milling as proxy in the South African context.	In 2004, 33 large mills produced 97% of the wheat flour in South Africa and 7 900 formal bakers and 64 900 informal bakers (this includes people baking for home industries and cake decorators) (NAMC, 2004 in Louw *et al.*, 2010)). The extraction rate from one tonne of wheat is 0.87 tonnes of brown bread flour and 0.76 tonnes of white bread flour (NAMC, 2006 in Louw *et al.*, 2010)). The extraction rate for the most common brands of maize meal sold in South Africa is 55% (NDA, n.d) The processing losses from wheat milling is therefore 28% and from Maize milling is 45%. The midpoint between 28% and 45% is 36.5%
	Roots and Tubers	Losses during cassava processing in Africa	Potato followed by sweet potatoes are the main root crops produced in South Africa (Alleman *et al.,* 2004). It is therefore inappropriate to use cassava as proxy for roots and tubers in South Africa.	Processing plants peel the potatoes as part of the production of crisps, instant potatoes and similar products. The produced waste is 90kg per tonne of influent potatoes and is apportioned as 50kg of potato skins, 30kg starch and 10kg inert material (Arapoglou *et al*., 2010)
	Oilseeds and Pulses	Expert opinion	It is not clear what informed the expert opinion for sub-Saharan Africa. A South Africa specific assumption would be more appropriate.	Boshoff (2008: 117) reports 6% refinement losses for sunflower oil. Oil extraction rate of 46% based on mean moisture free oi concentration (%) based on national cultivar trial evaluation (BFAP, 2014: 43).
	Fruit and Vegetables	Typical losses during small-scale fruit and vegetable processing	Fruit and vegetable processing in South Africa is undertaken by large-scale processors. It is therefore inappropriate to use small scale processing as a proxy for the South African context.	Oelofse and Muswema (2018) calculated the losses of fruit and vegetables during processing in South Africa. Adding these losses and calculating the losses as a percentage of the fruit and vegetables taken in for processing resulted in 32% losses/waste generated.

	Commodity	Assumption used in the 2013 estimate (Gustavsson et al., 2013)	Nature of the weakness/flaw	More appropriate assumption
	Meat	European beef slaughtering: "trimming scraps" 0.7-3%, European pig slaughtering "Others" 3-6%. Similar losses are assumed for sub-Saharan Africa	The assumption is based on European meat processing and is therefore considered an appropriate assumption for the South African context.	In South Africa, meat trimming scraps and offal (internal organs, intestines) are also consumed (ARC, 2021). The assumption for South Africa is therefore <1%.
	Fish and seafood	Losses during traditional fish processing in Nigeria	Bony fish - as anchovy (fishmeal production), hake (fish filleting), and pilchard (canning) - are at 76% the most common seafood processed in South Africa (Jeebhay *et al.,* 2004). Traditional processing as undertaken in Nigeria is therefore not an appropriate proxy for South Africa	SADSTIA (2021) report the following conversion factors for fish: Hake = 1.62 (average conversion for headed and gutted fish plus filleted at a 20:80 ratio). This is equal to 62% loss for hake. Sardines = 2.66 (average conversion from can contents (fish only) to whole fish weight) = 37.59% loss for sardines Tuna = 1.16 (average for all tuna species). = 16% Applying a weighted average loss based on the percentage of all fish by type being processed in South Africa (hake accounting for 0.25%; sardine canning accounting for 86.74%; and Tuna accounting for 13%) (SADSTIA, 2021) result In an assumed loss of 33%.
	Milk	0.5% based on Tuszynski, 1978 (FAO report)	It is inappropriate to use international data where local South African data is available.	Product loss in the dairy processing industry is about 3% (milksa.co.za)

	Commodity	Assumption used in the 2013 estimate (Gustavsson et al., 2013)	Nature of the weakness/flaw	More appropriate assumption
Distribution	Cereals	Expert opinion	An international expert with limited regional experience made the assumption.	In the absence of a South African estimate we stick to the expert opinion used for sub-Saharan Africa
	Roots and Tubers	Expert opinion	An international expert with limited regional experience made the assumption.	Le Roux *et al.*, (2017) report distribution losses of roots and tubers produced in Gauteng as 2.3%.
	Oilseeds and Pulses	Expert opinion	An international expert with limited regional experience made the assumption.	In the absence of a South African estimate we stick to the expert opinion used for sub-Saharan Africa
	Fruit and Vegetables	Based on losses at wholesale and retail markets in Ghana, Rwanda and Benin	South African wholesale and retail markets are linked to large supermarket chain stores. It is therefore inappropriate to use countries which rely on more local markets as a proxy for South Africa	Le Roux *et al.,* (2017) report distribution losses of fruit and vegetables produced in Gauteng as 5.5%.
	Meat	Expert opinion	An international expert with limited regional experience made the assumption.	In the absence of a South African estimate we stick to the expert opinion used for sub-Saharan Africa 7%.

	Commodity	Assumption used in the 2013 estimate (Gustavsson et al., 2013)	Nature of the weakness/flaw	More appropriate assumption
	Fish and seafood	Refrigerated well-functioning marketing system facilities are lacking or inadequate. Warm ambient climate combined with inadequate services in physical markets.	Refrigerated well-functioning marketing system facilities are available and in use in South Africa. It is therefore inappropriate to base estimates on inadequate refrigeration and marketing systems.	In the absence of a South African estimate we recommend using the same percentage as for meat i.e. 7%
	Milk	Milk losses at market in Uganda	An international expert with limited regional experience made the assumption.	Primary data sourced from a large dairy company in South Africa indicate average losses relating to damage during transport, in the warehouse as well as expired product combined as 3.4% per year
Consumption	Cereals	Expert opinion	South African specific data is available.	Self-reported food waste as a percentage of purchase y households is 14.5% (Venter, 2017)
	Roots and Tubers	Expert opinion	South African specific data is available.	Data from Le Roux *et al.,* (2017) suggest 1.5%
	Oilseeds and Pulses	Expert opinion	An international expert with limited regional experience made the assumption.	Self-reported food waste as a percentage of purchased oils and condiments 17% (Oelofse and Marx-Pienaar, 2016)
	Fruit and Vegetables	Expert opinion	An international expert with limited regional experience made the assumption.	Self-reported food waste as a percentage of purchase y households is 20.5% (midpoint of fruit and vegetables) (Venter, 2017)
	Meat	Expert opinion	An international expert with limited regional experience made the assumption.	In the absence of a South African estimate we stick to the expert opinion used for sub-Saharan Africa
	Fish and seafood	Expert opinion	An international expert with limited regional experience made the assumption.	In the absence of a South African estimate we stick to the expert opinion used for sub-Saharan Africa
	Milk	Expert opinion	An international expert with limited regional experience made the assumption.	Self-reported food waste as a percentage of purchase by households for dairy 14% (Venter, 2017)

Table 4: Revised food loss and waste as a percentage of food entering the stage of the supply chain in South Africa.

Commodity group	Agricultural production	Post-harvest handling & storage	Processing & Packaging	Distribution (Incl. Retail)	Consumption
Cereals	[1] 1	[2] 5.8	[3] 36.5	2	[4] 14.5
Roots and tubers	[5] 10	[6] 9.8	[7] 9	[8] 2.3	[9] 1.5
Oil seeds and pulses	[10] 1	[11] 38.4	[12] 60	2	[13] 17
Fruit and veg	[14] 9	[15] 18.3	[16] 31.6	[17] 5.5	[18] 20.5
Meat	[19] 6.03	[20] 5.22	[21] <1	7	[22] 10
Fish and seafood	[23] 0.75	[24] 0.44	[25] 31.1	[26] 7	2
Milk	[27] 1	[28] 12	[29] 3	[30] 3.4	[31] 14

Note: The percentages indicated in red have remained unchanged from the previous estimate due to unavailability of local South Africa estimates.

1 Combine harvesters are widely used by grain farmers in South Africa reducing harvest losses to below 1% (Rùsch, 2001: 2).
2 FAOSTAT 2021, refer to Table 2.
3 The midpoint of milling losses for maize and wheat in South Africa (Louw *et al.*, 2010; Finnie and Atwell, 2016)
4 Midpoint between 19% (bread) and 10% (cereals) (Venter 2017).
5 10% based on the lower value due to 80% of potatoes production being on large commercial farms (Oerke *et al*., 1999; Alleman *et al*., 2004)
6 FAOSTAT, 2021, refer to Table 2. This is in line with the findings by Viljoen *et al*., 2017).
7 Waste produced during the processing of potatoes is 90kg/tonne of influent potato (Arapoglou *et al*., 2010)
8 Based on Le Roux *et al.,* 2017
9 Based on Le Roux *et al.*, 2017
10 Harvesting losses for sunflower and canola using precision farming systems (Rùsch, 2001:2)
11 FAOSTAT 2021, refer to Table 2.
12 54% loss at 46% oil extraction rate (BFAP, 2014:43) plus 6% refinement losses for sunflower oil (Boshoff 2008:117)
13 Based on self-reported food waste as a percentage of purchased oils and condiments (Oelofse and Marx-Pienaar, 2016)
14 Primary data: Average estimated harvest losses for carrots, lettuce, cabbage, tomatoes, peppers, citrus, bananas, avocados, table grapes and pineapples by a sample of large scale farmers in SA
15 FAOSTAT 2021, refer to Table 2.
16 (Sum of all fruit and vegetable processing waste generated in 2012/13) divided by the Sum of all fruit and vegetables processed in 2012/13) x 100: this is calculated based on the findings from Oelofse and Muswema, 2018 (Refer to Appendix D).
17 Based on Le Roux *et al*., 2017
18 Based on Venter, 2017
19 A weighted average mortality rate for South Africa based on the kg/capita consumption of meat is 6.03% (ARC, 2021; Munzhelele *et al*., 2017; SAPA, 2017).
20 Weighted average losses for red meat and poultry(DAFF, 2015:3; ARC, 2021)
21 Based on primary data sourced from the ARC, 2021.
22 Based on Venter, 2017
23 Weighted average calculated based on primary data sourced from the South African Deep-Sea Trawling Industry Association (SADSTIA), 2021.
24 Weighted average calculated based on primary data sourced from the South African Deep-Sea Trawling Industry Association (SADSTIA), 2021
25 Weighted average calculated based on primary data sourced from the South African Deep-Sea Trawling Industry Association (SADSTIA), 2021.
26 The same percentage losses as for meat in sub-Saharan Africa is recommended by the project team.
27 The ABCD of using Milking Machines – Medilink Vet Suppliers (wordpress.com)
28 Midpoint of the milk losses reported for South Africa (DAFF, 2015:3)
29 REDUCTION OF PRODUCT LOSS IN DAIRY FOODS MANUFACTURING. | Milk South Africa (milksa.co.za)
30 Primary data: Losses during transport, in the warehouse and expired product returned to factory
31 Based on Venter 2017 for dairy.

3.2 Critical analysis of the methodology to calculate food waste

The methodology used for calculating food losses waste at the global level (Gustavsson *et al.,* 2011) provides a relatively simple approach, using assumptions about losses at each stage of the supply chain, for a number of different commodity groups by region. This approach allows for food loss and waste calculations in the absence of primary data by applying proxies. However, proxies must be relevant to the local conditions. Applying the 80:20 principle in instances where data for not all commodities per group are available, allow for estimates with a relative high confidence level.

Primary data allows for the calculation of percentage losses per commodity group at each stage of the value chain using weighted averages. The accuracy of the calculated percentage is dependent on the number of commodities in each group for which data are available. However, the methodology is silent on how to deal with data gaps, imports and exports of food. There is a general lack of information on the stage where the imports are dropped-in and where exports exit the value chain in any specific country. This is problematic, since the country of production is not necessarily the country of consumption, and the losses and waste are unevenly distributed across the value chain.

The environmental burden of having to manage food waste associated with food produced for the export market is carried by the country of origin, whereas the benefit of food security and consumption is realized in the importing country. From a global perspective, this may not be of much concern, since all food, losses and waste are accounted for at global scale, but it becomes important for regional or country level calculations. Countries that are net exporters of food may carry the environmental burden of a disproportionately high portion of global food losses and waste, when compared to net importers of food. Losses and waste occurring early in the supply chain needs to be managed in the country of production, whereas importing countries have to manage a relative small portion of the overall waste, which is typically associated with distribution and post-consumer losses at the final stages of the value chain. The current methodology only deals with net food supply and does not account for losses and waste associated with exports of foods. Furthermore, it does not distinguish between fresh and processed food imported or exported.

> *"Food" waste or loss is measured only for products that are directed to human consumption, excluding feed and parts of products which are not edible. Per definition, food losses or waste are the masses of food lost or wasted in the part of food chains leading to "edible products going to human consumption". Therefore, food that was originally meant to human consumption but which fortuity gets out the human food chain is considered as food loss or waste even if it is then directed to a non-food use (feed, bioenergy…). This approach distinguishes "planned" non-food uses to "unplanned" non-food uses, which are hereby accounted under losses.*
> *(Gustavsson et al., 2011)*.

The main challenge with applying this methodology in the local context is the lack of a clear definition of food losses and waste across the value chain and combined with the broad definition of food losses and waste applied in the global assessment (Gustavsson *et al.,* 2011). Losses resulting from food processing and diverted to other non-food product lines are typically not reported as losses or waste by the South African food industry, but is accounted for in the definition and consequently included in the calculations. The same applies to losses and waste occurring during production before the product becomes 'food'. Furthermore, different stages of the value chain sometimes overlap, resulting in losses and waste being combined into a single number. Disaggregation of such data into the relevant staged of the value chain is difficult, if not impossible. The result is that available data on food losses and waste in South Africa is not aligned with the definition used in the methodology. Therefore, for many commodities, the percentage losses and waste at each stage of the value chain remain best estimates rather than measured data. This disconnect is the result of research aimed at resolving food security issues, whereas reported food losses and waste are typically reported from a business perspective.

Although this approach is not ideal, for accurate assessments, it does provide a high-level indication of the magnitude of the problem at hand, as well as an indication of where in the value chain challenges are experienced and which commodities are most at risk of being lost for human consumption. The methodology can be replicated at any scale with relative ease, if the assumptions on the losses and waste at each stage of the value chain are reasonably accurate in the local context. The main benefit of this approach lies in the fact that comparable food supply data is available free of charge on the FAO website for most countries across the globe and data gaps can be filled using proxy data from other countries.

It is however important to ensure that the assumed percentage losses are as accurate as possible, and therefore stakeholder consultation throughout the value chain is required to estimate losses and waste in line with the definition. The main consideration for using proxy data entail accurate knowledge of the local conditions and practices. Aspects to consider include the scale and type of commodities produced the level of sophistication, and industrialisation across the value chain. Lastly, the culture and typical behavior around food during the consumption stage are also important aspects to consider. Applying this approach to calculating food waste estimates, allow for regular updates using accurate local data as it becomes available.

3.3 The updated food waste estimate for South Africa

The food waste estimate for South Africa is based on a mass flow model, based on food production, import and export data obtained from the Food and Agriculture Organisation of the United Nations (FAO). This data refers only to *edible* food and therefore the calculations will return data on the waste from the *edible* food portion. Furthermore, the 'distribution' stage includes wholesaler, supermarkets and retailers; while the 'consumption' stage refers to waste at the household level. This approach to estimating food waste is therefore a conservative estimate from a food security perspective.

Aggregating across the value chain for all commodity groups, the total quantity of food waste across the value chain in South Africa amounts to **10 332 770 tonnes** (Table 5)**.** This number represents the average food losses and waste incurred per annum, based on the average food supply over the 5-year period 2014-2018. This equates to 34.3% of the local production, and 45.4% of available food supply entering the food value chain (production plus imports less exports) in the country being lost or wasted. Although the order of magnitude is very similar to the 10.2 million tonnes estimated by

Nahman and de Lange (2013), the distribution of the waste across the different stages of the value chain has changed (Table 6).

This estimate is comparable with global estimates of between 30% (Gustavsson *et al.,* 2011) and 50% (IChemE, 2013). As mentioned earlier in the report, South Africa is a unique country in sub-Saharan Africa with modern food supply chains dominated by large supermarkets. The Institute of Chemical Engineers (2013) highlight the central role major supermarkets play in meeting consumer expectations, and the impact of supermarket standards for the physical characteristics, such as size and appearance, on food waste generation. This is also the case in South Africa as confirmed through interviews with local producers. Furthermore, the consumers in developed countries throw large quantities (30-50%) of food that they bought away (IChemE, 2013). A similar trend is observed in South Africa (Venter, 2017).

The results presented in Figure 1, clearly indicate that the majority (49%) of the losses and waste (once food has entered the food supply chain) stem from processing, followed by post-harvest handling and storage (19%). Consumption level waste contributes 18% of the waste. This is a significant finding for South Africa, since the waste at consumption stage in the value chain contributes a much larger portion as compared to previous estimates. The production losses are lower than previously estimated (Table 6), mainly due to the sophisticated farming and harvesting technologies used specifically in field crop production by large commercial farmers still dominating production, whereas the consumption losses are 18% as compared to the 5% from the previous estimates (Oelofse and Nahman, 2013; Nahman and de Lange, 2013).

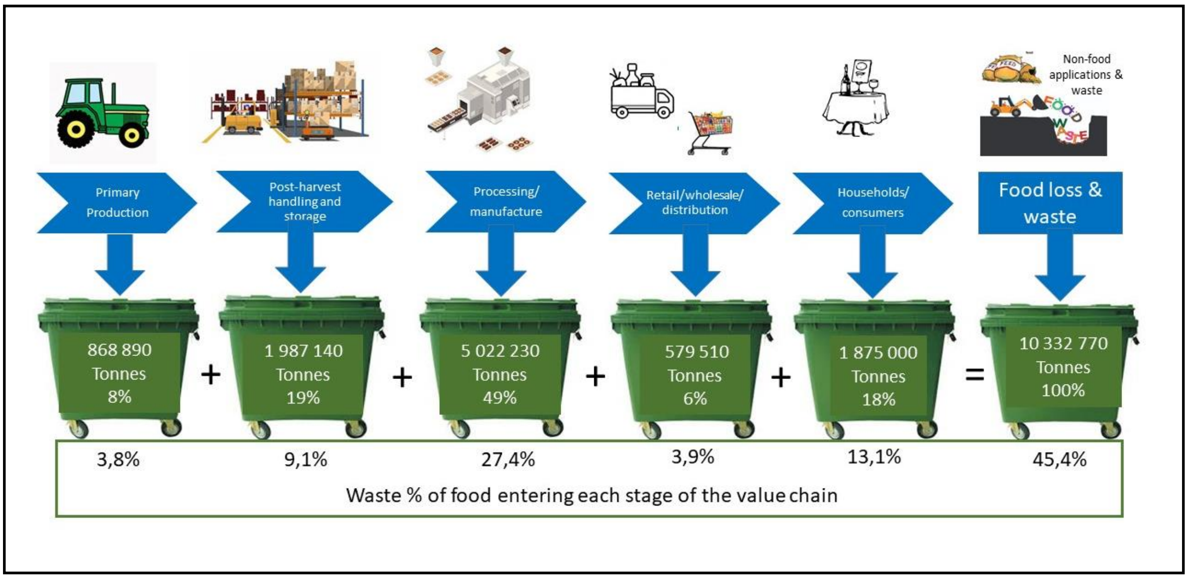

Figure 1: Average annual food losses and waste along the food value chain in South Africa (for the period 2014-2018)

Table 5: Quantities of food waste (in thousands of tonnes) at each stage of the value chain for South Africa (calculated based on data from FAOSTAT, 2021)

Commodity group	**Average annual food production (1000t)**		**Post-harvest handling and storage**		**Processing and Packaging**		**Distribution**		**Consumption**		**Total**
	Food entering	Food waste	Food entering	Food waste	Food entering	Food waste	Food entering	Food waste	Food entering	Food waste	Food waste
Cereals	10 265.60	102.66	10 162.94	589.45	9 573.49	3 494.33	6 079.17	121.58	5 957.58	863.85	5 171.86
Roots and tubers	1 818.00	181.80	1 636.20	160.35	1 475.85	132.83	1 343.03	30.89	1312.14	19.68	525.55
Oilseed and pulses	304.20	3.04	301.16	115.64	185.51	111.31	74.21	1.48	72.72	12.36	243.84
Fruit and vegetables	3 730.40	335.74	3 394.66	621.22	1 206.45*	381.24	2 392.20	131.57	2 260.63	463.43	1 933.20
Meat	3 576.80	215.68	3 361.12	175.45	3 185.67	0.00	3 185.67	223.00	2 962.67	296.27	910.40
Fish and seafood	366.44	2.75	363.69	1.60	362.09	119.85	242.24	16.96	225.28	4.51	145.66
Milk	2 722.40	27.22	2 695.18	323.42	2 371.75	782.68	1 589.08	54.03	1 535.05	214.91	1 402.26
Total	**22 783.84**	**868.89**	**21 914.95**	**1 987.14**	**18 360.82**	**5 022.23**	**14 905.58**	**579.51**	**14 326.07**	**1 875.00**	**10 332.77**
Waste % of food entering each stage of the value chain		3.81		9.07		27.35		3.89		13.09	

Note: * Based on Oelofse and Muswema 2018, it is estimated that 43.5% of all fruit and vegetables produced are send for processing. Therefore, only 43.5% of the output from the post-harvest handling and storage stage are assumed to enter the processing stage of the value chain. The remaining 56.5% (1 556.99 thousand tonnes) were again added to the input entering the distribution stage of the value chain. This was done to compensate for the fact that the 32% assumed losses during processing and packaging are based on processing losses only and calculated from Oelofse and Muswema, 2018.

Table 6: Percentage losses at each stage of the value chain

Stage in the value chain	Oelofse and Nahman (2013)	Nahman & de Lange (2013)	This study (2021)
Production	26	26	8
Post-harvest handling and storage	26	24	19
Processing	27	25	49
Distribution	17	20	6
Consumption	4	5	18

A different way of looking at the results is to consider the losses and waste as a percentage of the food entering each stage in the value chain (Table 5). The total losses during production is equal to 3.8% of the food entering this stage of the value chain, but account for 8.4% of the overall estimated losses and waste across the value chain. Similarly post-harvest handling and storage incur 9.1% losses, but contribute 19% of the overall estimated losses and waste. Processing result in a 27% reduction by weight, but contributes 49% of the overall losses and waste. These losses are the highest when compared to all other stages in the value chain, but can be explained. Unavoidable food waste (peels, pips, bones, skins, heads, etc.) occurs during processing while this is also where the most value is added. Furthermore, packaging and processing extends the shelf life of the food in question, which in turn reduces the wastage further down the value chain. In addition, most of the food losses incurred up to this stage of the value chain are not considered wastage by the food industry stakeholders as it typically finds its way into other value-add products, some related to the food industry (e.g. the extraction of enzymes) but also other non-food applications, including animal feed.

Distribution losses are 3.9% but it contribute 5.6% to the overall losses and waste, while consumption waste at 13% contributes 18% of the waste. The waste at the consumption stage is of concern due to the high intrinsic value of food that made it through to this stage in the value chain, and the limited options for diverting this waste to other uses. The retail sector is committed to food rescue and donations, but consumers revert to feeding pets, home composting or disposal of the waste into the municipal bin (Ramakhwatho, 2016). Implementation of waste prevention strategies as contained in the 'Food Waste Prevention and Management Guideline for South Africa' (DEFF and CSIR, 2021) should be encouraged to reduce avoidable waste throughout the value chain, and industry should be encouraged to join the Voluntary Agreement on Food Waste Reduction driven by the Consumer Goods Council of South Africa.

The contribution to the overall waste per commodity group is illustrated in Figure 2. Cereals contribute half of all the losses and waste, followed by fruit and vegetables (19%), milk (14%), meat (9%), roots and tubers (5%). The contribution per commodity group is different to the previous estimates. Cereals are estimated to contribute 50% of the total food waste. This is nearly double when compared to the previous estimate of 26%. Fruit and vegetables contribute 19% of the waste as compared to the previous estimate of 44%. The main reason for this difference is the fact that the previous assumption assumed that all fruit and vegetables goes for processing whereas the updated assumption is that only 43.5% of fruit and vegetables are processed. The updated assumption is based on actual reported percentages of fruit and vegetables sent for processing in South Africa. The calculated food waste (tonnes) reported by Oelofse and Muswema (2018) per commodity was added together and divided by the sum of the tonnages sent for processing to derive at the aggregated percentage waste during processing for this commodity group. The difference in the relative contribution of food waste quantities in each commodity group between the current and previous estimates to the total quantity of food waste in South Africa is presented in Table 7.

Table 7: Relative contribution of food waste quantities in each commodity group to the total quantity of food waste in South Africa (% by mass)

Commodity group	Oelofse and Nahman (2013)	Nahman & de Lange (2013)	This study (2021)
Cereals	28	26	50
Roots and Tubers	10	9	5
Oilseeds and Pulses	1	4	2
Fruits and Vegetables	47	44	19
Meat	5	7	9
Fish and Seafood	1	2	1
Milk	8	8	14

4 Conclusions and recommendations

The methodology used for the early food waste estimates for South Africa (Oelofse & Nahman, 2013) was tested and found to still be appropriate from a food security perspective. However, the sub-Saharan Africa assumptions adopted for the 2013 study, are not in all cases aligned with local conditions. South Africa is more industrialised when compared to the rest of sub-Saharan Africa and produces food at a large commercial scale. Farming sizes are typically larger than the rest of the region. The average farm size in South Africa is 237ha (DRDLR, 2017) and the majority of farms in sub-Saharan Africa is 5-100ha (Jayne *et al.*, 2019). Furthermore, production systems more sophisticated (Oelofse *et al*., 2020), and as a result, the on-farm losses and wastage are typically lower than estimated for the rest of the region. Furthermore, processing plants are highly industrialised and the retail market in South Africa is highly dependent on supermarket chain stores, whereas the rest of the region, is less industrialised focussing on small-scale processing, and the retail markets are more informal. Having said that, the current estimated losses throughout the supply chain for South Africa have applied the 80:20 principle and therefore focussed on the formal economic activities, which dominate the local food value chain.

The percentage loss for each commodity groups at every stage of the value chain, with the exception of cereal (distribution), oilseed and pulses (distribution), meat (distribution) and fish and seafood (consumption), were revised based on local South African conditions. It certainly provides a local flavour and is based on actual data, although the majority of the assumptions are based on small local studies, which are not necessarily representative of the country. The new South African specific assumptions presented are based on sound evidence and have been circulated for review by relevant industry experts. Comments and input received in time for the finalisation of this report have been considered, but additional comments forthcoming after the publication of this report will be used to further refine assumptions before publication of the results in a scientific journal.

The updated estimate of food losses and waste for South Africa is 10.3 million tonnes per annum, which is in the same order of magnitude of the previous estimates. This equates to 34.3% of the local production, but 45.4% of available food supply entering the food value chain in the country being lost or wasted. The difference between the previous and this estimate is in the spread of the losses and waste along the value chain, as well between commodity groups. This study found that the majority of the losses (82%) occur at pre-consumer level, but the waste generated during consumption has increased from the previously reported 5% (Oelofse & Nahman, 2013) to 18% (as reported here). This is cause for concern since consumption stage waste is of high value with limited re-purposing options and often avoidable. Reducing consumption stage waste is challenging due to the requirement to change human perceptions and behaviour. The publication of the 'Food Waste Prevention Guideline for South Africa' (DEFF and CSIR, 2021) is the first step in the right direction to raise awareness and provide guidance on food waste reduction.

It is recommended that research on food losses and waste should continue to improve our knowledge of the current losses and waste incurred at each stage of the value chain for all commodity types. The primary data collected during this project clearly indicated that we need more large studies to enable extrapolations of data to larger areas. Furthermore, the focus on the research to date was largely on the formal economy whereas there is a national drive promoting small-scale farming and entrepreneurial development in rural areas. More research is therefore required on the informal or less formal food production and processing systems along the food value chain.

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Annexure A: Food Balance Sheets for South Africa

According to the FAO a "*Food Balance Sheet presents a comprehensive picture of the pattern of a country's food supply during a specified reference period. The food balance sheet shows for each food item - i.e. each primary commodity and a number of processed commodities potentially available for human consumption - the sources of supply and its utilization. The total quantity of foodstuffs produced in a country added to the total quantity imported and adjusted to any change in stocks that may have occurred since the beginning of the reference period* [and subtracting the amount exported] *gives the supply available during that period"* (FAOSTAT). On the utilization side the balance sheet draw a distinction between the quantities fed to livestock, used for seed, put to manufacture for food use and non-food uses, losses during storage and transportation, and food supplies available for human consumption. The Balance sheets also calculate the per capita food supply by dividing the available domestic supply of food by the population. (FAOSTAT).

Food balances per main commodity group 2014-2018 (FAOSTAT, 2021)

South Africa - 2014															Food Balance Sheet			
Item	Pop.	Domestic Supply					Domestic Utilisation								Per Capita Supply			
		Prod.	Imp.	Stock Var.	Exp.	Total	Food	Proc.	Feed	Seed	Losses	Oth. Use	Tourist	Resid.	Total		Prot.	Fat
	-1000	(1000 tonnes)													Kg/Yr	KCal/Day	g/Day	
Population	54544					0												
Grand Total																2976	85.45	80.97
Vegetal Products																2500	48.52	47.75
Animal Products																476	36.93	33.22
Cereals - Excluding Beer		16699	3736	439	3384	16612	10194	710	5102	65	601			-60	186.9	1527	40.74	10.21
Starchy Roots		2310	62	-114	178	2308	1778	0	222	55	170	84		0	32.6	64	1.33	0.09
Pulses		105	75	-3	11	173	139	7	13	11	5			0	2.54	23	1.53	0.1
Oilcrops		2010	305	-79	62	2332	134	2102	122	13	112	1		-152	2.45	25	1.73	1.78
Vegetables		2641	217	-14	348	2524	2253	38	82		215			-64	41.31	36	1.33	0.27
Fruits - Excluding Wine		7009	239	-61	3669	3639	1702	1504	0		459	2		-28	31.21	42	0.51	0.26
Meat		3207	417	8	136	3479	3467		2			27		-17	63.57	329	24.62	24.77
Milk - Excluding Butter		3337	83	3	291	3126	2564	325	304					-67	47.01	81	4.77	4.81
Fish, Seafood		601.26	284.71	-3	403.59	479.38	389.39		89.94			0.05			7.14	14	1.99	0.57

South Africa - 2015															Food Balance Sheet			
Item	Pop.	Domestic Supply					Domestic Utilisation								Per Capita Supply			
		Prod.	Imp.	Stock Var.	Exp.	Total	Food	Proc.	Feed	Seed	Losses	Oth. Use	Tourist	Resid.	Total		Prot.	Fat
	-1000	(1000 tonnes)													Kg/Yr	KCal/Day	g/Day	
Population	55386					0												
Grand Total																2942	86.49	83.02
Vegetal Products																2458	49.36	49.13
Animal Products																483	37.12	33.89
Cereals - Excluding Beer		11984	3328	-3161	1873	16601	9858	723	5570	57	433			-40	177.99	1453	38.39	10.01
Starchy Roots		2552	63	36	186	2394	1789	0	245	59	188	113		0	32.3	64	1.32	0.09
Pulses		92	51	-23	12	153	125	5	10	9	4			0	2.26	21	1.36	0.09
Oilcrops		1940	305	-315	74	2486	290	1978	139	13	103	2		-39	5.24	49	5.07	2.87
Vegetables		2864	211	-6	325	2757	2446	41	87		232			-49	44.17	38	1.4	0.29
Fruits - Excluding Wine		7205	227	95	3719	3617	1629	1539	0		477	2		-29	29.4	39	0.49	0.23
Meat		3272	385	4	152	3501	3508		2			29		-37	63.33	330	24.5	25.03
Milk - Excluding Butter		3538	79	10	239	3368	2683	335	364					-14	48.44	84	4.95	4.97
Fish, Seafood		570.61	233.89	-1	319.97	483.54	361.67		121.82			0.05			6.53	12	1.8	0.49

				South Africa - 2016											Food Balance Sheet			
Item	Pop.	Domestic Supply					Domestic Utilisation								Per Capita Supply			
		Prod.	Imp.	Stock Var.	Exp.	Total	Food	Proc.	Feed	Seed	Losses	Oth. Use	Tourist	Resid.	Total		Prot.	Fat
	-1000						(1000 tonnes)								Kg/Yr	KCal/Day	g/Day	
Population	56208					0												
Grand Total																2921	84.58	81.41
Vegetal Products																2434	46.99	47.36
Animal Products																487	37.59	34.05
Cereals - Excluding Beer		10283	6755	-1499	2006	16531	10319	735	5063	76	380			-43	183.59	1498	40	10.02
Starchy Roots		2212	64	-212	156	2332	1808	0	214	51	163	96		0	32.17	63	1.32	0.09
Pulses		53	79	-1	22	110	92	4	9	5	2			-1	1.63	15	0.99	0.07
Oilcrops		1656	438	258	77	1759	136	1850	121	13	99	1		-461	2.42	24	1.71	1.73
Vegetables		2729	198	1	421	2505	2294	46	52		221			-108	40.82	36	1.3	0.27
Fruits - Excluding Wine		6490	255	-113	3835	3023	1190	1521	0		429	2		-118	21.17	29	0.36	0.17
Meat		3244	567	4	165	3642	3642		2			30		-32	64.8	335	25.1	25.28
Milk - Excluding Butter		3549	115	11	275	3378	2700	346	355					-23	48.04	83	4.91	4.93
Fish, Seafood		617.51	256.38	-1.01	504.57	368.31	347.14		21.12			0.04			6.18	11	1.7	0.43

				South Africa - 2017											Food Balance Sheet			
Item	Pop.	Domestic Supply					Domestic Utilisation								Per Capita Supply			
		Prod.	Imp.	Stock Var.	Exp.	Total	Food	Proc.	Feed	Seed	Losses	Oth. Use	Tourist	Resid.	Total		Prot.	Fat
	-1000						(1000 tonnes)								Kg/Yr	KCal/Day	g/Day	
Population	57010					0												
Grand Total																2936	83.64	82.53
Vegetal Products																2470	48.35	49.73
Animal Products																465	35.29	32.8
Cereals - Excluding Beer		18942	4351	2665	3095	17532	10523	753	5345	64	867			-20	184.58	1511	40.25	10.46
Starchy Roots		2531	55	-26	195	2418	1841	0	242	59	186	90		0	32.29	64	1.32	0.09
Pulses		86	56	0	29	114	90	3	9	9	4			-1	1.58	15	0.96	0.07
Oilcrops		2420	139	175	68	2315	211	1883	157	17	123	1		-76	3.7	36	2.81	2.48
Vegetables		2844	208	3	390	2660	2404	49	50		230			-74	42.16	37	1.36	0.28
Fruits - Excluding Wine		6851	262	-21	4120	3013	1132	1483	0		460	1		-64	19.86	28	0.35	0.13
Meat		3131	570	-10	147	3564	3563		2			28		-29	62.49	322	24.19	24.27
Milk - Excluding Butter		3643	128	10	285	3476	2785	350	375					-34	48.85	85	5	5.01
Fish, Seafood		528.75	282.96	5.01	424.52	392.21	366.99		25.18			0.04			6.44	12	1.75	0.45

				South Africa - 2018											Food Balance Sheet			
Item	Pop.	Domestic Supply					Domestic Utilisation								Per Capita Supply			
		Prod.	Imp.	Stock Var.	Exp.	Total	Food	Proc.	Feed	Seed	Losses	Oth. Use	Tourist	Resid.	Total		Prot.	Fat
	-1000						(1000 tonnes)								Kg/Yr	KCal/Day	g/Day	
Population	57793					0												
Grand Total																2899	84.37	82.93
Vegetal Products																2420	48.33	49.01
Animal Products																479	36.03	33.92
Cereals - Excluding Beer		15057	4024	-296	3117	16260	10434	649	4443	72	672			-11	180.54	1473	39.63	9.83
Starchy Roots		2554	57	43	188	2380	1874	0	178	59	187	82		0	32.43	64	1.33	0.09
Pulses		87	52	0	26	114	90	3	10	8	4			-1	1.56	14	0.94	0.06
Oilcrops		2634	86	-162	96	2786	214	2332	74	56	128	2		-21	3.71	35	3.5	2.09
Vegetables		2709	203	5	376	2531	2288	39	53		219			-68	39.58	35	1.29	0.27
Fruits - Excluding Wine		7257	324	29	4460	3093	1314	1424	0		469	2		-116	22.74	30	0.41	0.18
Meat		3241	576	-15	121	3711	3704		2			27		-22	64.09	331	24.74	24.99
Milk - Excluding Butter		3753	87	22	277	3541	2880	402	275					-16	49.83	86	5.08	5.1
Fish, Seafood		528.75	282.96	5.01	424.52	392.21	366.99		25.18			0.04			6.35	11	1.73	0.44

Annexure B: Meat data used in calculations

The weighting for meat losses is based on the average consumption per person per year as calculated below unless otherwise indicated.

	Per capita consumption in Kilogram									
	2010	2011	2012	2013	2014	2015	2016	2017	Average	Percentage
Poultry	**38,4**	**39,9**	**39,4**	**39,4**	**38,6**	**39,6**	**40**	**41,2**	**39,5625**	**60**
beef	17,8	17,6	16,7	17,4	18,5	19,5	20,9	21,3	18,7125	28
pork	4,4	4,6	4,6	4,7	4,5	4,7	4,8	5	4,6625	7
lamb and mutton	3,5	3,1	3	3,3	3,6	3,5	3,6	3,7	3,4125	5
Total red meat	**25,7**	**25,3**	**24,3**	**25,4**	**26,6**	**27,7**	**29,3**	**30**	**26,7875**	**40**
Total consumed	**64,1**	**65,2**	**63,7**	**64,8**	**65,2**	**67,3**	**69,3**	**71,2**	**66,35**	
https://www.statista.com/statistics/963216/per-capita-consumption-of-meat-by-type-south-africa/										
Statsta, 2021.										

Agricultural Production

Data on pre-and post-weaning mortalities and losses in ruminants (ARC, 2021) are:

Private land

	Cattle	Sheep	Goats
Deaths	2.16%	2.02%	0.19%
Predation	0.1% – 0.9% Midpoint 0.5%	3% - 13% Midpoint 8%	
Stock theft	0.45%	0.34%	0.67%
Total (using midpoint for predation)	3.11	10.36	8.86

Communal land

	Cattle	Sheep	Goats
Deaths	4.72%	1.73%	2.73%
Predation	8.0% – 11.0% Midpoint 9.5	0.5% - 19% Midpoint 9.75	
Stock theft	Not reported separate from private land		
Total	14.22	11.48	12.48

According to the South African Institute of International Affairs (A Profile of the South African Beef Market Value Chain | SAIIA) there is a 60:40 split between commercial beef production and small scale and emerging farmers. The weighted average loss for cattle is therefore 7.55%

Piglet mortality of 1-10% pre-weaning and 1-5% post-weaning is reported (Munzhelele, et al., 2017).

Calculating the **weighted average for red meat**:
Weighted average loss for cattle as calculated above = 7.55% at 28% of all meat consumed
Assuming very little contribution by small scale sheep farmers = 10.36% at 5% of all meat consumed
Piglet mortality based on the midpoint for pre- and post-weaning combined = 7.38% at 7% of all meat consumed.

The weighted average for red meat = 7.87%

Annexure C: Fish and Seafood data used in calculations

A host of different fish species is harvested in South Africa. For the purposes of this study we focus on the three most important fish species, which accounts for the bulk of the fish and seafood supply in the South African food supply chain.

Total calculated whole catch in tonnes after conversion factors have been applied (excluding post-harvest but before landing losses (spoilage, discards) (SADSTIA 2021)

	Hake Annual Catches				Sardine Annual Catches				Tuna Annual Catches		
	M. para	M. cap	Total		Dir	Bycatch	Total		Pole	Longline	Total
2009	82,576	28,354	110,930		89 202	5 125	94 327				
2010	89,087	26,098	115,185		87 710	24 707	112 417				
2011	97,142	32,525	129,667		89 046	23 092	112 138				
2012	102,616	25,050	127,666		97 948	11 543	109 491				
2013	109,316	20,071	129,387		88 051	4 101	92 152			4630	
2014	121,295	21,361	142,656		89 090	8 619	97 709			5314	
2015	113,286	22,217	135,503		79 848	15 358	95 206		2927	5254	
2016	114,948	25,889	140,837		63 412	16 988	80 400		2642	2877	
2017	108,600	25,488	134,088		31 379	6 215	37 594		2755	2499	
2018	98,715	32,655	131,370		31 035	1 654	32 689		2901	2901	
Average	103,758	25,971	**129,729**		74 672	11 740	**86 412**		2806	3913	**6719**

Note: 55-65% of the sardine catch is canned. The remainder as well as all bycatch are processed into fishmeal.

Data used in the calculations as provided by SADSTIA (2021):

Hake
Post-harvest before landing losses: 2-3% (including damaged, spoiled, or too small but excl. predation)
Depredation: 2% (fish removed from gear by predators before hauling)
Conversion factor: 1.62 (average conversion for headed and gutted plus filleted weighted 20:80)

Sardines
Post-harvest before landing losses: 0.5% (including damaged, spoiled, or too small but excl. predation)
Depredation: 0.1% (fish removed from gear by predators before hauling)
Conversion factor: 2.66 (average conversion from canned contents (fish portion only) to whole)

Tuna
Post-harvest before landing losses: 0% (large fish are immediately blast frozen, so no loss)
Depredation: <5%% (Longline only)
Conversion factor: 1.16 (average conversion for all tuna species)

Annexure D: Fruit and Vegetable processing calculations

The data used by Oelofse and Muswema (2018) in their calculations of food waste during fruit and vegetable processing are as follows:

Commodities	Processed	Waste (Oelofse and Muswema, 2018)
Deciduous fruit	589 140	184 290
Subtropical fruit	131 313	22 980
Citrus Fruit	560 456	224 128
Vegetables	184 450	32 278
Total	**1 465 359**	**463 676**

The total waste divided by total production = 31.6% wastage

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