Estimating the magnitude of food waste generated in South Africa

Suzan H.H. Oelofse and Anton Nahman

CSIR – Natural Resources and the Environment, Pretoria, South Africa

Corresponding Author: SHH Oelofse, CSIR – Natural Resources and the Environment, P.O. Box 395, Pretoria, 0001, South Africa.

Email: soelofse@csir.co.za.

Key words

Food waste, Food losses, Food security, Food supply chain, Organic waste, Developing country

Abstract

Throughout the developed world, food is treated as a disposable commodity. Between one third and half of all food produced for human consumption globally is estimated to be wasted. However, attempts to quantify the actual magnitude of food wasted globally are constrained by limited data, particularly from developing countries. This paper attempts to quantify total food waste generation (including both pre-consumer food losses and post-consumer food waste) in South Africa. The estimates are based on available food supply data for South Africa and on estimates of average food waste generation at each step of the food supply chain for sub-Saharan Africa as reported in Gustavsson et al. (2011). The preliminary estimate of the magnitude of food loss and food waste generation in South Africa is in the order of 9.04 million tonnes per annum. On a per capita basis, overall food loss in South Africa in 2007 is estimated at 177 kg/capita/annum and consumption waste at 7 kg/capita/annum. However, these preliminary figures should be used with caution and are subject to verification through ongoing research.

Introduction

Attempts to quantify food waste are motivated by the need to assess the scale of waste in relation to global malnutrition (Parfitt et al. 2010) and to improve the climate for

recovering and composting source-separated organic waste (Massachusetts Department of Environmental Protection 2002). Food waste is composed of raw or cooked food materials and includes food waste before, during and after meal preparation in the household; as well as food losses in the process of food manufacturing, distribution, retail and food services activities (European Commission 2010). Food losses refer to a decrease food quantity and quality, which makes it unfit for human consumption (Grolleaud 2002). Food waste is a potentially important factor in efforts to combat hunger and improve food security in poor countries (Gustavsson et al. 2011). At the same time, organic waste (including garden and food waste) is a problematic waste stream in landfills, where it contributes to greenhouse gas emissions (Hartman & Ahring 2006).

The aim of this paper is to quantify the magnitude of food waste in South Africa, in order to inform future action to reduce and better manage the food waste problem. The goal of the paper is to provide a preliminary assessment of food waste generation at various stages in the food supply chain in South Africa, as part of ongoing research.

Problems associated with food waste

Food waste gives rise to three inter-related problems. The first relates to food security. According to the 2010 State of Food Insecurity in the World report (FAO 2010), a total

of 925 million people globally – almost one in seven people – are estimated to be undernourished. Developing countries account for 98 percent of the world's undernourished people (FAO 2010). A 2008 study revealed that 70% of poor urban households in South Africa live in conditions of 'significant' or 'severe' food insecurity (Frayne et al. 2009). To meet the challenge of feeding growing populations and addressing food insecurity, massive reductions in the amount of food wasted after production are needed (Lungqvist et al. 2008).

The second problem relates to greenhouse gas emissions along the food supply chain. On average, greenhouse gas emissions throughout the food supply chain range between 2.8 and 4.14 tonnes of carbon dioxide equivalent (tCO_2e) per tonne of food; broken down as follows (Bakas 2010):

- Manufacturing/processing (including agriculture): between 1.95 and 2.29 tCO_2 e per tonne of food
- Distribution and retail: between 0.1 and 0.8 tCO_2 e per tonne of food
- Consumption: between 0.3 and 0.6 tCO_2 e per tonne of food
- End-of-life (landfill): 0.45 tCO_2e per tonne of food

Potential inefficiencies in the food value chain therefore have the potential to contribute up to 4.14 tCO_2e per tonne of food wasted, contributing a significant component of a

country's emission footprint. While the disposal of organic waste (including food waste) is estimated to contribute 4.3% to South Africa's greenhouse gas emissions, agriculture contributes 9.3% to the country's greenhouse gas emissions (DEA 2009; DEA 2010).

Finally, the third problem relates to waste disposal. Landfilling is generally considered the most practical and cheapest waste management method in South Africa. However, the scarcity of available land in close proximity to areas of waste generation, as well as emissions of landfill gas (with high concentrations of methane), have made landfilling a less attractive management option (Hartmann & Ahring 2006). For example, the disposal of organic waste (including food waste) is estimated to contribute 4.3% to South Africa's greenhouse gas emissions. Introducing alternative end-of-life treatment technologies for food waste could therefore reduce the greenhouse gas emission s from food waste and should therefore be considered.

Indeed, disposal of organic waste (including food waste) to landfill is outlawed in many countries (DEA 2010) including Germany, Sweden, Canada; and the phasing out of these practices is now also a priority in South Africa (DEA 2011). Municipalities have to take responsibility for diverting organic waste to composting or biogas digesters (DEA 2011). Waste from food processing could also be a source of valuable, functional compounds such as antioxidants (Schieber et al. 2001). Cheap, renewable and abundant

sources of antioxidant compounds are in high demand (Moure et al. 2001). Continued research in this field is therefore essential, but requires fairly accurate data on waste quantities and composition at the different stages in the food supply chain. Furthermore, accurate estimates of food waste would assist municipalities to meet their obligations in terms of national priorities.

Food losses in the Food Supply Chain

Food losses occur at all stages in the food supply chain, from initial agricultural production to final household consumption (Gustavsson et al. 2011); including during food storage, transportation, food processing, at retailers and in the kitchens of restaurants, hotels and households (Lundqvist et al. 2008). A review of food waste in the global food supply chain (Parfitt et al. 2010) found that "as much as half of all food grown is lost or wasted before and after it reaches the consumer" (Lundqvist et al. 2008: 4). Other studies suggest that roughly one third of food produced for human consumption is lost or wasted globally (Gustavsson et al. 2011). This means that resources used in the production of this food are also wasted, while the greenhouse gas emissions caused by the production of wasted food are generated in vain (Gustavsson et al. 2011).

There is a diversity of causes of food wast throughout the food supply chain. Post-harvest losses are influenced by available technologies and the extent to which markets for agricultural produce have developed (Parfitt et al., 2010). Causes of household food waste vary considerably from one area to another, as a result of cultural practices, climate, diet and socio-economic factors (e.g. household size, household income and frequency of eating out) (European Commission 2010). Parfitt et al. (2010) identified three interrelated drivers influencing food losses:

- *Urbanisation and the contraction of agricultural markets*. Extended food supply chains are required to supply food to an increasing urban population. These require improvements in road, transportation and marketing infrastructure, while keeping food affordable for the poor.
- *Dietary transition*. Growth in household incomes, especially in developing countries, results in changes in dietary patterns from consumption of starchy food staples to more diversified diets. Dietary transition leads to increased consumption of vulnerable, short shelf-life items such as fruit and vegetables, resulting in greater food waste (Lunqvist et al. 2008).
- *Increased globalisation of trade*. Agricultural exports may present a threat to the development of domestic markets. Global food trade increases transport distances in the food supply chain, consequently increasing food losses.

Total per capita food losses throughout the food supply chain in Europe and North America amount to 280-300 kg/annum, compared to 120-170 kg/annum in Sub-Saharan Africa and South/Southeast Asia (Gustavsson et al. 2011). The proportion of food wasted specifically by consumers on a per capita basis is much higher in developed countries (95-115 kg/annum in Europe and North America) than in developing countries (6-11 kg/annum in Sub-Saharan Africa and South/Southeast Asia) (Gustavsson et al. 2011). The causes of food losses and waste in low-income countries are mainly connected to financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult climatic conditions, infrastructure, packaging and marketing systems. By contrast, the causes of food losses and waste in medium/high income countries mainly relate to consumer behaviour and to a lack of coordination between different actors in the supply chain (Gustavsson et al. 2011).

A study on food wasted in the United Kingdom (WRAP 2008) showed that consumers throw away about one third of the food that they buy. Parfitt et al. (2010) quotes international studies conducted in various countries, indicating that food waste at the household level varies between 8% (Netherlands) and 25% (USA) of food purchased. Much of this food 'waste' (e.g. 61% in the United Kingdom) is still suitable for human consumption (WRAP 2008) and can therefore be considered avoidable. The most common reason provided by consumers for food being wasted is that it is left unused

(61% of the avoidable waste) or that too much has been cooked or prepared (WRAP 2008). Production of food that is not consumed while fit for human consumption results in wasted resources at the production stage while it further contributes to food insecurity. Furthermore, food waste disposed of on landfills contributes significantly to the environmental impacts of waste.

Food waste in South Africa

No primary data collection has been undertaken during this research to date. Therefore the results are based on available data and assumptions as reported in literature and described herein. The results should be used with caution, as they reflect a preliminary assessment of food waste generation in South Africa. However, research is ongoing to provide more accurate results in the future.An extensive search for available data on food waste generation in South Africa was conducted. Landfill site records, waste information databases as well as municipal integrated waste management plans were scrutinised for data on food waste.Data extracted from the South African waste information system (SAWIS) was disappointing, with only four sites reporting food waste data between 2007 and 2010. Landfill data obtained from metropolitan municipalities revealed that, in general, municipalities record pre-consumer food losses, requiring safe disposal certificates, although this data is not necessarily reported. This lack of reported data on food waste could be explained by the fact that waste separation

at source only became a legal requirement in South Africa in 2009 (Republic of South Africa 2008), while reporting to the SAWIS is still voluntary and not yet required at this level of detail. Reporting to the SAWIS is expected to become mandatory in 2012 (Baloyi 2011).

Of the 112 municipal waste management plans reviewed, only two reported food waste figures. This is not surprising when considering that very few waste characterisation studies have been undertaken in South Africa. Sibernagl (2011) reports that two studies were undertaken in Johannesburg and another two in the Western Cape, with some work in Rustenburg and Bloemfontein. A report on another such study conducted in Limpopo was published in 2011 (Ogola et al. 2011).

The waste characterisation study by Jarrod Ball and Associates (2001) conducted in the City of Johannesburg found that putrescible waste (most of which is assumed to be food waste) varies depending on household income level and site. From available studies it seems that waste from low income households in urban areas contains a higher proportion of food waste by weight (12-26.2%) as compared to high income households (7-7.6%). This can be explained by the fact that food is a basic need - poor households therefore spend a higher proportion of their budgets on food as compared to high income households (Martins 2007). In addition, poor households can be expected to

throw less other waste types away, due to their restricted budget for buying non-food items. However, the Limpopo study (covering a more rural area) reports higher food waste proportions in high income households as compared to low income households (Ogola et al. 2011). The seemingly contradictory results from the Limpopo study highlight the urgent need for more representative waste characterisation studies covering both rural and urban areas in South Africa.

The available waste related data was therefore not very useful to estimate food losses at a national level, as they are not statistically representative. It was only possible to estimate food waste generation figures for South Africa based on data on food production (FAOSTAT 2010a; 2010b) and on estimates of proportions of food waste at various stages of the food supply chain (Gustavsson et al. 2011), as explained in the following section.

Research Method

Our estimates of food waste in South Africa are based on some of the results of studies carried out by the Swedish Institute for Food and Biotechnology (SIK) as reported by the Food and Agriculture Organisation (FAO) of the United Nations (Gustavsson et al. 2011) for sub-Saharan African countries. These studies highlighted the food losses

(referring only to edible parts of the commodities) occurring along the food supply chain, and made assessments and assumptions of the magnitude of these losses, focussing on quantitative weight losses. Estimates of food waste at each stage of the food supply chain in sub-Saharan Africa (as a percentage by weight of the food entering each step), as estimated for various commodity groups by Gustavsson et al. (2011), are presented in Table 1.

Table 1: Estimated/assumed waste percentage for each commodity group in each step of the food supply chain for sub-Saharan Africa (Gustavsson et al. 2011).

Commodity group	Agricultural production	Post harvest handling and storage	Processing and packaging	Distribution	Consumption
Cereals	6.0%	8.0%	3.5%	2.0%	1.0%
Roots and Tubers	14.0%	18.0%	15.0%	5.0%	2.0%
Oil seeds & Pulses	12.0%	8.0%	8.0%	2.0%	1.0%
Fruits and Vegetables	10.0%	9.0%	25.0%	17.0%	5.0%
Meat	15.0%	0.7%	5.0%	7.0%	2.0%
Fish and Seafood	5.7%	6.0%	9.0%	15.0%	2.0%
Milk	6.0%	11.0%	0.1%	10.0%	0.1%

Based on estimates in Table 1, it was possible to calculate the food losses at each stage of the food supply chain in South Africa based on production figures for each corresponding commodity group. The production of food commodities in each country, including in South Africa, is recorded and reported annually by the Food and

Agriculture Organisation of the United Nations. South African food production figures are summarised in Table 2. The production volumes for all commodities except fish and seafood were collected from the FAO Statistical yearbook 2010 (FAOSTAT 2010b). Data for fish and seafood were collected from the FAO Food Balance Sheets (FAOSTAT 2010a). The same commodity groupings as used by Gustavsson et al. (2011) were used. Food production figures per commodity group in South Africa are presented in Table 2.

Table 2: Food production per commodity group in South Africa (FAOSTAT, 2010; 2010a).

Commodity Group	PRODUCTION (1000 tonnes)			
	2007	**2008**	**2009**	***2007-2009 (Average)***
Cereals	*9 514*	15 363	14 586	*13154*
Roots and Tubers	*2 023*	2 147	1 882	*2017*
Oil seeds and Pulses	*261*	535	563	*453*
Fruits and Vegetables	*8 109*	8 417	8 162	*8230*
Meat	*2 138*	2 179	444	*1587*
Fish and seafood	*673*	No data	No data	*224*
Milk	*3 066*	3 200	3 091	*3119*
Total Production	*25 785*	31841	28 729	*28 785*

Food waste at each step of the food supply chain for each commodity group in South Africa was calculated using the percentages as outlined in Table 1. Since production figures for the different commodities vary year-on-year, it was decided to use the

average production figures over a 3 year period (2007-2009) as indicated in the last column of Table 2 to estimate annual food waste generation. Since Gustavsson et al.'s (2011) food loss percentages refer to percentages (by weight) of food *entering each stage*, it was assumed that the amount of food entering each stage equals the amount of food entering the previous stage, less food losses at that stage. The food loss calculated at each stage of the food supply chain was therefore subtracted from the production figure for that stage *before* the calculation for the next stage was done. For example, agricultural production, minus losses during agricultural production, equals the input figure for the calculation of waste generated during the post harvest handling and storage stage of the food supply chain, and so on.

The international food waste estimates presented by Gustavsson et al. (2011) were based on 2007 data. Thus, to present food waste estimates for South Africa in per capita terms (useful for comparison with other countries), it was necessary to use food production and population data from the same year, namely 2007. Population statistics for 2007 were obtained from Statistics South Africa (StatsSA 2010).

Results and discussion

The results of the analysis are presented in Table 3. Using the method described in the previous section, the preliminary average estimate for food waste in South Africa is in the order of 9.04 million tonnes per annum. This amounts to 31.4% of average annual agricultural production (28.79 million tonnes per annum) (Table 3).

Table 3: Calculated average per annum food waste generation figures for South Africa (2007-2009).

Commodity group	Production 2007-2009 (average) (1000 Tonnes)	Waste (1000 Tonnes)						
		Agricultural production	Post harvest handling and storage	Processing and packaging	Distribution	Pre-consumer waste	Consumption	Total waste per commodity group
Cereals	13154	789.3	989	398	220	2396	108	2504
Roots and Tubers	2017	282.4	312	213	60	869	23	892
Oil seeds & Pulses	453	54.4	32	29	7	122	3	126
Fruits and Vegetables	8230	823.0	667	1685	859	4034	210	4244
Meat	1587	238.1	9	67	89	404	24	427
Fish and Seafood	224	12.8	13	18	27	71	3	74
Milk	3119	187.1	323	3	261	773	2	775
Total per stage of the food supply chain	**28785**	**2387.0**	**2344.6**	**2413.4**	**1523.0**	**8668.2**	**372.7**	**9040.9**

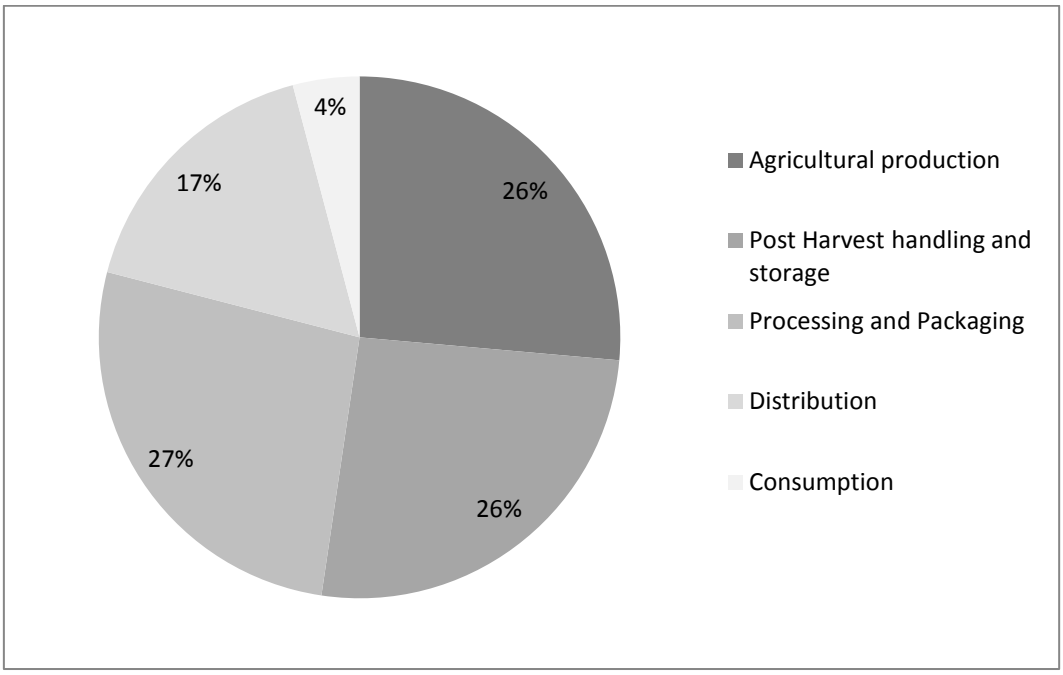

Figure 1: Percentage contribution of each step in the food supply chain to total average food waste in South Africa

The percentage contribution to total food waste at each step in the food supply chain is illustrated in Figure 1. The split in waste generation between agricultural production, post harvest handling and storage, and processing and packaging is fairly equal. The majority (8.67 million tonnes per annum or 95.9%) of the food waste generated annually is generated during the pre-consumer stages. Pre-consumer food waste amounts to 30.1% of average annual agricultural production. Only 4.1% (0.37 million

tonnes) of the total food waste is generated at the consumption (post-consumer) stage; amounting to 1.3% of agricultural production.

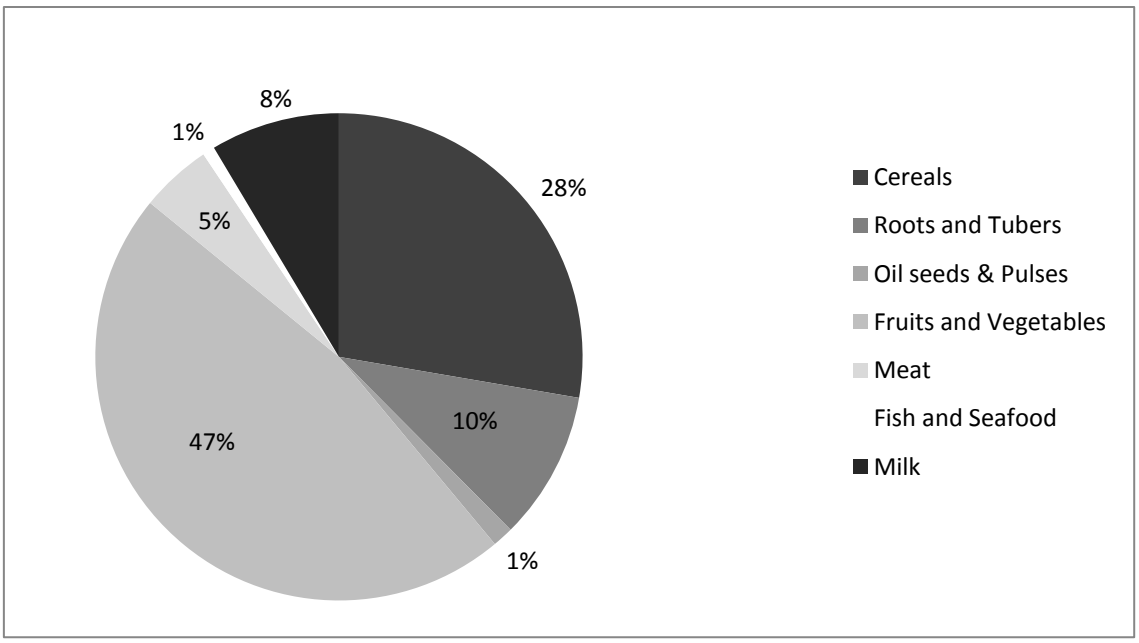

Figure 2: Percentage contribution of each commodity group to total average food waste in South Africa.

The contribution of each commodity group to total food waste is illustrated in Figure 2. It is evident that fruit and vegetables, combined with roots and tubers, contribute 57% of the overall food waste stream; while fish, seafood and meat contribute only 6%. Focussed efforts to reduce wastage of fruit and vegetables could therefore have a significant impact on overall food waste generation rates in South Africa. However,

efforts to reduce meat waste is also important in order to reduce the environmental impacts of food waste (the production of meat protein has a much higher environmental load than processed protein food based on soybeans (Reijnders & Soret, 2003)).

In order to compare the results of this study with findings in the literature (Gustavsson et al. 2011), the 2007 per capita food waste generation for South Africa was calculated following the same approach as described above, but using the 2007 food production dataset rather than the three-year average as used above. The calculated food waste generation for 2007 is provided in Table 4.

Table 4: Calculated food waste in South Africa in 2007

Commodity group	Domestic supply (2007)	Waste (Tonnes)						
		Agricultural production	Post harvest handling and storage	Processing and packaging	Distribution	Pre-consumer waste (waste generated from production up to and including distribution)	Consumption waste	Total waste generated per commodity group
Cereals	9514	570.9	715	288	159	1733	78	1811
Roots and Tubers	2023	283.2	313	214	61	871	23	894
Oil seeds & Pulses	261	31.4	18	17	4	71	2	72
Fruits and Vegetables	8109	810.9	657	1660	847	3975	207	4182

Meat	2138	320.8	13	90	120	544	32	576
Fish and Seafood	673	38.4	38	54	81	212	9	221
Milk	3066	184.0	317	3	256	760	2	762
Total	**25785**	**2239.5**	**2072**	**2326**	**1528**	**8165**	**353**	**8518**

In 2007, 8.52 million tonnes of food waste was generated by a population of 48.26 million (StatsSA 2010). Per capita food waste generation in South Africa in 2007 is therefore calculated as 177 kg/capita. This figure seems reasonably accurate when compared to the per capita estimated food loss of 170 kg/annum for sub-Saharan Africa estimated by Gustavsson et al. (2011). Post-consumer food waste (353 000 tonnes per annum) accounts for 7 kg/per capita/annum, as compared to 6 kg/per capita/annum in sub-Saharan Africa estimated by Gustavsson et al. (2011). The slightly higher per capita figures for South Africa as compared to sub-Saharan Africa is expected, since South Africa has the highest gross domestic product (GDP) of all sub-Saharan African countries (World Bank 2011) and there are indications of a strong correlation between a country's GDP and waste generation (EPD 1998). Furthermore, South Africa has the second highest consumption per capita after Liberia (World Bank 2005).

The above estimates are likely to understate total food waste generated in South Africa. FAOSTAT data for 2007 (FAOSTAT 2007) suggest that South Africa is a net importer of food, while the above calculations were based on local production figures only. Food loss in the food supply chain of imported products should therefore also be included in the calculations in order to provide a more realistic picture. In addition, South Africa is

characterised by two parallel economies; the so-called ‘first’ or ‘formal’ economy, which is similar in nature to a developed country economy; and the ‘second’ or ‘marginalised’ economy (Vermeulen & Bienabe 2007). In parallel to well developed formal retail chain groups in the formal economy; a very large and growing informal market, especially for fresh fruit and vegetables, characterises the ‘second’ economy. The calculations above are based only on agricultural production in the formal economy. The informal market could potentially generate significant amounts of pre-consumer food waste due to inadequate transport, cooling and storage facilities; which is not accounted for here.

Conclusions

Food waste has a triple negative impact: Firstly, disposal of food waste at landfill impacts on the environment through atmospheric (particularly greenhouse gas) emissions, leachate, odours and pests. Secondly, atmospheric emissions caused by food production, processing and distribution of food to consumers are wasteful if the food is not used. Thirdly, wasted food exacerbates the problem of food insecurity.

In light of the threats associated with global change and considering the concern over food security in large parts of the developing world (Gustavsson et al. 2011), it is

important to understand the magnitude of food waste globally. This paper sheds some light on the situation in South Africa, and forms part of ongoing research.

The calculated food waste estimate of approximately 9.04 million tonnes per annum in South Africa is conservative and likely to be an underestimate given the assumptions made. Therefore, it is recommended that the highly aggregated results presented here be verified through primary data collection throughout the food supply chain. A more accurate assessment of food waste could facilitate better waste management practices towards reducing greenhouse gas emissions and improving food security in South Africa.

Acknowledgements

The authors would like to thank the officials of various metropolitan municipalities for sharing landfill data. The efforts of Ms Manja Schubert in scrutinising municipal integrated waste management plans, and of Ms Linda Godfrey in extracting data from the SAWIS and providing valuable comments on earlier versions of this paper, are also acknowledged. The constructive comments of two anonymous reviewers are also acknowledged. This research was funded by the CSIR through the Parliamentary Grant budget.

Reference

Bakas, I. (2010) Food and Greenhouse Gas (GHG) Emissions. *Corpus.* The SCP Knowledge Hub. Available from: http://www.scp-knowledge.eu/sites/default/files/KU_Food_GHG_emissions.pdf (accessed 6 January 2012).

Baloyi, O. (2011) Personal Communication. Director: Waste Policy and Information Management for the Department of Environmental Affairs and Tourism, Pretoria, South Africa.

DEA (Department of Environmental Affairs). (2009) Greenhouse Gas Inventory South Africa 1990 to 2000: National Inventory Report. Compilation under the United Nations Framework Convention of Climate Change. Department of Environmental Affairs, Pretoria, South Africa.

DEA (Department of Environmental Affairs). (2010) National waste management strategy - First draft for public comments, Department of Environmental Affairs, Pretoria, South Africa.

DEA (Department of Environmental Affairs). (2011) National Waste Management Strategy, November 2011, Department of Environmental Affairs, Pretoria, South Africa.

European Commission. (2010) Preparatory study on food waste across EU 27. Technical Report – 2010-054.

Environmental Protection Department. (1998) Waste data and statistics: Monitoring of solid waste in Hong Kong 1998. The government of the Hong Kong, Special Administrative Region.

FAO (Food and Agriculture Organisation). (2010) The State of Food Insecurity in the World: Addressing food insecurity in prostrated crises. Food and Agriculture Organisation of the United Nations, Rome, Italy.

FAOSTAT (2010a). Food and Agriculture Organisation of the United Nations. Food balance sheet for South Africa. Available from: http://faostat.fao.org/site/368/DesktopDefault.aspx?PageID=368 (accessed 6 December 2011).

FAOSTAT. (2010b) FAO Statistical Yearbook 2010: Agricultural production. Available from: http://www.fao.org/economic/ess/ess-publications/ess-yearbook/ess-yearbook2010/en/ (accessed 6 December 2011).

Frayne, B., Battersbey-Lennard, J., Fincham, R. & Haysom, G. (2009) Urban food security in South Africa: Case study of Cape Town, Msunduzi and Johannesburg. Development Planning Division Working Paper Series No 15, DBSA Midrand, South Africa.

Godfrey, L. (2008) Facilitating the improved management of waste in South Africa through a national waste information system. *Waste Management* 28: 1660-1671.

Grolleaud, M. (2002) Post-harvest losses: Discovering the full story. Overview of the phenomenon of losses during the Post-harvest System. FAO, Rome (Italy). Agricultural Support Systems Div. Available from: http://www4.fao.org/cgi-bin/faobib.exe?rec_id=559824&database=faobib&search_type=link&table=mona&back_path=/faobib/mona&lang=eng&format_name=EFMON (accessed 16 January 2012).

Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R. & Meybeck, A. (2011) Global food losses and food waste: Extent, Causes and Prevention. Study conducted for

the International Congress SAVE FOOD! At Interpack 2011, Düsseldorf, Germany. Food and Agriculture Organisation of the United Nations, Rome, Italy .

Hartmann, H. & Ahring, B.K. (2006) Strategies for the anaerobic digestion of the organic fraction of municipal solid waste: an overview. *Water Science and Technology*, 53(8): 7-22.

Jarrod Ball & Associates (2001) Current waste management in the City of Johannesburg: A waste stream analysis of the general waste stream. DANCED Environmental Capacity Building Project, Johannesburg. Mini-project WM4 on metro-wide waste management planning – Phase 1. Report No 1A.

Lundqvist, J., de Fraiture, C. & Molden, D. (2008) Saving Water: From Field to Fork – Curbing Losses and Wastage in the Food Chain. SIWI Policy Brief.

Martins, J. (2007) The South African Consumer Market. *Global Journal of Business Research* Volume 1(1) 168-183.

Massachusetts Department of Environmental Protection (2002) Identification, characterisation and mapping of food waste and food waste generators in Massachusetts. Final Report.

Moure, A., Cruz, J. M., Franco, D., Dominguez, J. M., Sineiro, J., Dominguez, H., Nunez, M. J., & Parajo, J. C. (2001) Natural antioxidants from residual sources. *Food Chemistry*, 72, 145–171.

Ogola, J.S., Chimuka, L., & Tshivhase, S. (2011) Management of municipal solid wastes: A case study in Limpopo Province, South Africa, in: Kumar, S. (Ed.), Integrated Waste Management, Volume 1, InTech, Rijeka, Croatia.

Parfitt, J., Barthel, M. & Macnaughton, S. (2010) Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society: Biological Sciences*. 365: 3065-3081.

Reijnders, L. & Soret, S. (2003) Quantification of the environmental impact odf different dietary protein choices. *The American Journal of Clinical Nutrition.* 78(supplement): 664S-668S.

Republic of South Africa (2008) National Environmental Management: Waste Act, 2008 (Act No 59 of 2008).

Schieber, A., Stintzing, F.C. & Carle, R. (2001) By-products of plant food processing as a source of functional compounds – recent developments. *Trends in Food Science & Technology* 12: 401-413.

Sibernagl, P. (2011) What's the composition of your domestic waste stream? Is there value in recycling? In: *The Waste Revolution Handbook.* Chapter 19. p137-141.

StatsSA (2010a) General Household Survey 2010. Statistical release P0318. Available from: http://www.statssa.gov.za/publications/P0318/P0318June2010.pdf (accessed 6 Sept 2011).

Vermeulen, H., & Bienabe, E. (2007) What about the food 'quality turn' in South Africa? Focus on the organic movement development. Poster prepared for presentation at the 105th EAAE Seminar 'International Marketing and International Trade of Quality Food Products', Bologna, Italy, March 8-10, 2007.

World Bank,(2005) International Comparison Programme - Regional Summary for Sub-Saharan Africa. World bank, Washington, D.C. United States of America.

World Bank (2011) World Development Indicators database, World Bank 1 July 2011. Available from: http://siteresources.worldbank.org/DATASTATISTICS/Resources/GDP.pdf (accessed 15 December 2011).

World food programme (2009) World hunger Series: Hunger and the markets. London, UK. Earthscan. Available from: http://home.wfp.org/stellent/groups/public/documents/communications/wfp200279.pdf (accessed 16 May 2011).

WRAP (2008) The food we waste: Report. Banbury, UK. Available from: http://wrap.s3.amazonaws.com/the-food-we-waste.pdf (accessed 26 May 2011).