FOODFORWARD SA

Estimate of the GHG emission reductions due to FoodForward SA operations

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Authors: Matthew Burke, Alexandra Logan and Yvonne Lewis

The Green House
Ubunye House
70 Rosmead Avenue
Kenilworth
7708
t: + 27 (0) 21 671 2161
e: info@tgh.co.za

Project: 22066

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1 INTRODUCTION

FoodForward SA is an organisation that contributes to reducing widespread hunger in South Africa by recovering surplus food from the consumer goods supply chain and ensuring it is redistributed to Non-Profit Organisations (NPOs) through a number of different programmes. The Warehousing FoodBanking programme involves FoodForward SA sourcing and collecting surplus food from various donor manufacturers, wholesalers and retailers, which is transported to FoodForward SA warehouses for storage and subsequent collection by NPOs. The FoodShare programme, involves FoodForward SA connecting NPOs and donors through the FoodShare virtual application, allowing NPOs to collect food directly from these donors. Together these programmes redistributed close to 80,000 tonnes of food to 2,225 beneficiary organisations in the last four-years, helping to feed almost 900,000 beneficiaries daily.

The recovery and redistribution of surplus food has the additional benefit of reducing the greenhouse gas (GHG) emissions associated with the food supply chain. From a life cycle perspective, it reduces the amount of food waste sent to landfill and avoids the need for additional food to be produced to meet the needs of the various beneficiaries. FoodForward commissioned this updated report to estimate the GHG emission reductions from their Warehouse FoodBanking and FoodShare programmes between 2019 and 2022.

This report presents the system considered for analysis, as well as the methodologies used to estimate the GHG emission reductions. A summary of the estimated GHG emission reductions achieved by FoodForward SA operations between 1 March 2019 and 22 December 2022 is then presented.

2 SYSTEM FOR ANALYSIS

The food life cycle includes various stages, namely: production, processing, transport, storage, retail, preparation by consumers and final consumption. In a scenario where FoodForward SA does not operate, food is produced, processed, transported, stored and sent to a retailer. If this food is surplus to requirements it is discarded: transported to a waste disposal site and landfilled. Food needs to be purchased to meet the nutritional needs of the beneficiaries of the NPOs. Thus, more needs to be produced – essentially repeating the life cycle up until the retail stage – before being sold to the NPOs for preparation and consumption by the beneficiaries.

With intervention from FoodForward SA, the surplus food is transported from retailers and wholesalers to NPOs – either via the FoodForward SA warehouses or directly via the FoodShare programme – and is then prepared and consumed. In this scenario the surplus food does not end up in landfill and, as the food meets the needs of the beneficiaries, it avoids the need for additional food to be produced.

These two scenarios are presented in Figure 1, where it can be noted that the production, processing, storage and transport of food to retailers (i.e. the "cradle-to-retail" life cycle emissions) is common in both scenarios. Similarly, the final preparation and consumption of the food is common in both scenarios. The differences between the two scenarios is be attributed to three stages, namely:

- Avoided food production, processing and transport: In the scenario where FoodForward SA operates, it avoids the need for food to be produced, processed and transported to meet the needs of the beneficiaries. FoodForward SA operations therefore avoid the "cradle-to-retail" life cycle emissions.
- Avoided waste disposal emissions: In the scenario where FoodForward SA does not operate the food is transported to a waste disposal site and disposed of. This stage produces emissions from the transport

of the surplus food, landfill operations and from the degradation of the surplus food. FoodForward SA operations can therefore be assumed to mitigate emissions associated with waste disposal.

- Difference in the transport of food from retailers to NPOs: Between the scenarios, there is a difference in the emissions associated with the transport of surplus food from the retailers to the NPOs. In the scenario where FoodForward SA operates, transport to the NPOs is either via the FoodForward SA warehouses (T_B and T_C) or directly through the FoodShare operations (T_D). At the FoodForward SA warehouses the food is stored and in certain cases refrigerated. Warehouse operation therefore results in the consumption of electricity that would not occur without the redistribution programmes (FFSA). Without FoodForward SA operations, it is assumed that transport is only directly between the retailers and the NPOs (T_A).

Total GHG emission reductions associated with these life cycle stages due to FoodForward SA operations are calculated according to the following equation:

Total emissions avoided = Avoided Waste Emissions + Avoided cradle-to-retail emissions + Transport emissions to NPOs without food donations - Transport emissions to NPOs with food donations – Warehouse operational emissions

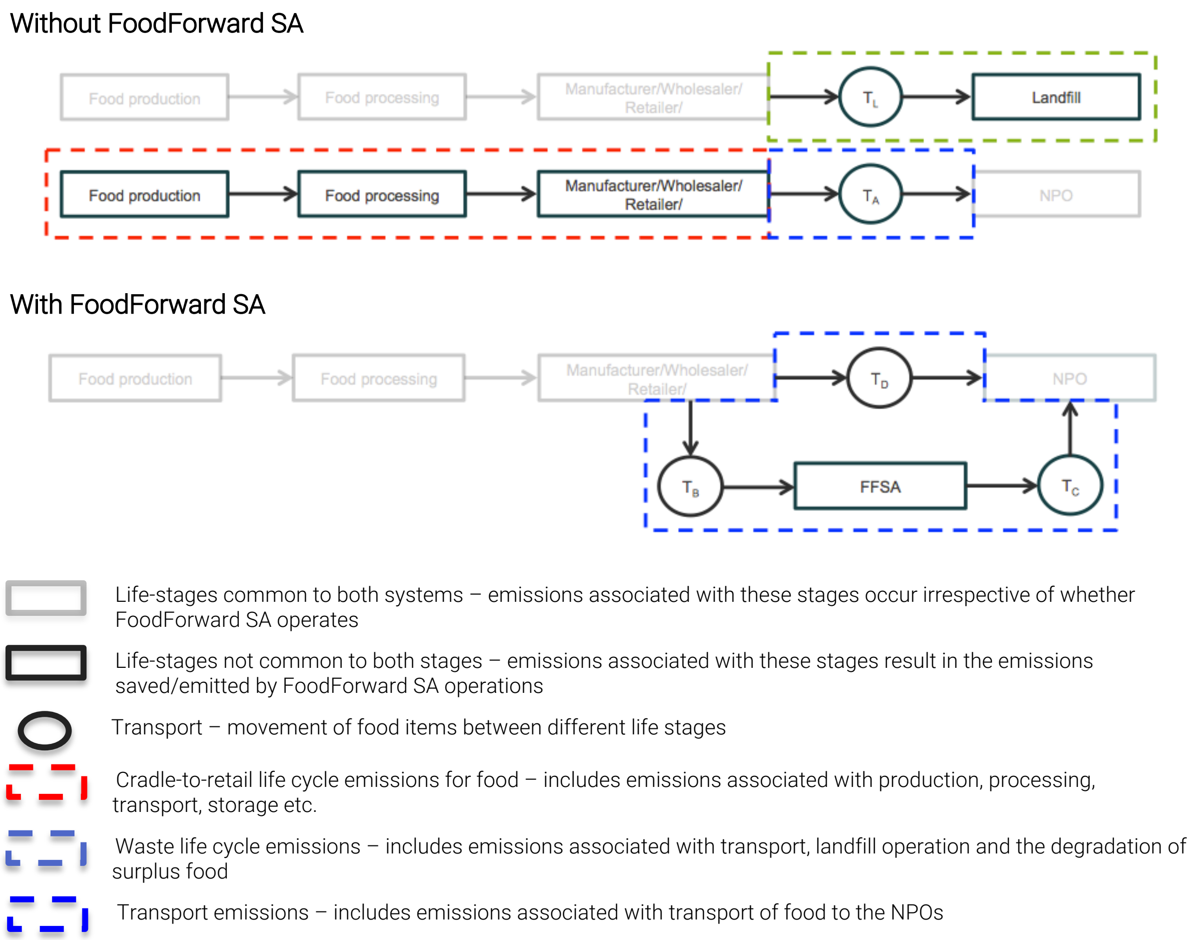

Figure 1: System diagram for scenarios with and without FoodForward SA operations

3 METHODOLOGY

The following section details the methodology, assumptions and data used to estimate the GHG emission reductions due to FoodForward SA operations.

3.1 FoodForward SA data collection

Data on FoodForward SA operations was readily available in electronic format and was supplemented with information gathered during a meeting with FoodForward SA at their Nerissa Estate headquarters on 13 December 2022. The electronic data included the following information:

- Mass of surplus food redistributed through FoodForward SA operations.
  - Mass broken down by programme (Warehouse FoodBanking and FoodShare programmes).
  - Mass broken down by food product type.
- Expenditure on fuel for the transport of food from donors to FoodForward SA warehouses.
- Expenditure on electricity for FoodForward SA warehouse operations.

The disaggregation level by food product type varied according to data age (older data was more aggregated); programme (Warehouse FoodBanking data had a higher level of disaggregation, as the food is stored and redistributed at the FoodForward SA warehouses, while FoodShare data reported by donating organisations was more aggregated); and donating organisation.

3.2 Cradle-to-retail emissions saved

Cradle-to-retail GHG emission savings were estimated by multiplying the sub-category food quantities by a cradle-to-retail GHG emission factor (cradle-to-retail EF). This mathematical equation is given below in Equation 1.

$$Cradle - to - retail\ emissions\ (kg\ CO_2e) = Food\ quantity\ (kg)\ \times\ Cradle - to - retail\ EF\ (\frac{kg\ CO_2e}{kg\ food}) \qquad 1$$

The cradle-to-retail emission factors are based on TGH's proprietary adaptations of ecoinvent, Agribalyse and World Food LCA database datasets, which ensure that the datasets are a more accurate representation of South Africa's food systems. The use of these factors is an update from the previous report, where the majority of emission factors were sourced from international literature and only a limited number of food types had South African specific values. As noted above, some data is recorded at an aggregated level and in these cases the cradle-to-retail emission factor is based on a weighted average of all applicable values in the disaggregated data (e.g. dairy is based on the weighted average EF for milk, long-life milk, yoghurt, cheese etc.).

3.3 Disposal emissions saved

Waste disposal emission savings were estimated using the methodology and data presented in *GHG emission factors developed for the collection, transport and landfilling of municipal waste in South African Municipalities* (Friedrich and Trois 2013) and the updated IPCC Guidelines (IPCC 2019).The 2013 study included methodologies and data for the estimation of emissions from the transport of waste, landfill construction and operations and the degradation of waste. A key assumption is that all surplus food recovered and redistributed by FoodForward SA would have been disposed of into the formal municipal waste stream (i.e. sent to a landfill site).

3.3.1 Waste transport emissions

Fuel use for waste transport was estimated by multiplying the tonnage of surplus food recovered by FoodForward SA by the average diesel use for transport per tonne of waste in South African municipalities. This mathematical equation is given below in Equation 2. The waste transport emissions were then estimated by multiplying the diesel usage by the diesel emission factor, as given in Equation 3.

$$Diesel\ usage\ (L) = Food\ quantity\ (tonnes)\ \times\ Diesel\ usage\ for\ transport\ (\frac{L}{tonne\ waste}) \quad (2)$$

$$Diesel\ emissions\ (kg\ CO_2e) = Diesel\ usage\ (L)\ \times\ Diesel\ EF\ (\frac{kg\ CO_2e}{L}) \quad (3)$$

The factors used in these equations are presented in Table 1. Diesel usage for waste transport per tonne of waste is a South African specific factor determined in the study by Friedrich and Trois (2013).

Table 1: Factors for the estimation of waste transport emissions

Constant	Units	Value	Reference
Diesel usage for waste transport	L / tonne waste	4.9	(Friedrich and Trois 2013)
Diesel emission factor	kg CO_2e / L	2.87	(DEA 2017; IPCC 2019)

3.3.2 Landfill construction and operation emissions

Diesel usage for landfill construction and operation was estimated by multiplying the tonnage of surplus food recovered by the diesel usage per tonne of waste for construction and operation, as given below in Equation 4. The diesel usage emissions were then estimated by multiplying the diesel usage by the diesel emission factor (Equation 3).

$$Diesel\ usage\ (L) = Food\ quantity\ (tonnes)\ \times\ (Diesel\ usage\ for\ construction + Diesel\ usage\ for\ operation\ (\frac{L}{tonne\ waste})) \quad (4)$$

Similarly, electricity usage for operation was estimated by multiplying the tonnage of surplus food recovered by the electricity usage per tonne of waste for operation, as given in Equation 5. Electricity usage emissions were then estimated by multiplying the electricity usage by the electricity emission factor (Equation 6).

$$Electricity\ usage\ (kWh) = Food\ quantity\ (tonnes)\ \times Electricity\ usage\ for\ operation\ (\frac{kWh}{tonne\ waste}) \quad (5)$$

$$Electricity\ emissions\ (kg\ CO_2e) = Electricity\ usage\ (kWh)\ \times\ Electricity\ EF\ (\frac{kg\ CO_2e}{kWh}) \quad (6)$$

The emissions from the use of synthetic liner and cover material were estimated by multiplying the tonnage of surplus food recovered by the emission factors per tonne of waste for synthetic liners and sand/gravel/rock usage (Equation 7).

$$Material\ use\ emissions\ (kg\ CO_2e) = Food\ quantity\ (tonnes) \times (Synthetic\ liner\ EF + Sand\ EF\ \left(\frac{kg\ CO_2e}{tonne\ waste}\right)) \quad (7)$$

The factors used in the above equations are given in Table 2.

South Africa does not publish an electricity emissions factor for use in greenhouse gas reporting, and thus emission factors for South African grid electricity vary depending on the source. Most practitioners use the emission factor as provided in Eskom annual reports. The Green House, however, prefers to follow the latest thinking in this regard and follow the approach in the NBI *South Africa's Grid Emission Factor* report (NBI 2013). This method takes into account the electricity purchased from independent power producers and imported from the South African Power Pool to modify Eskom's grid emissions factor to a more accurate value. In this report the information was updated based on generation, import and purchased data for the Eskom 2020/21 financial year (DoE 2020; Eskom 2021).

Table 2: Factors for the estimation of landfill construction and operation emissions

Constant	Units	Value	Reference
Diesel usage for construction and operation	L / tonne waste	2.0	(Friedrich and Trois 2013)
Electricity usage for daily operation	kWh / tonne waste	2.0	(Friedrich and Trois 2013)
Electricity emission factor	kg CO_2e / kWh	0.95	(NBI 2013; DoE 2020; Eskom 2021)
Emissions from construction	kg CO_2e / tonne waste	2.1	(Friedrich and Trois 2013)

3.3.3 Emissions from the degradation of food waste

Food disposed of in a landfill degrades into methane (CH_4) and biogenic carbon dioxide. The rate at which methane is released depends on the characteristics of both the waste material and the disposal site. Food waste decomposes rapidly, resulting in a quick release of methane and carbon dioxide and minimal storage of undegraded carbon within the landfill site. The landfill site design and how it is operated determines how anaerobic the decomposition process is, with well-managed landfill sites effectively operating completely anaerobically (i.e. the decomposition of degradable organic carbon occurs without oxygen, resulting in the formation of methane) (IPCC 2019). In South Africa, many landfills are unmanaged (especially in rural areas), and some larger landfill sites are only partially managed. In these cases, the landfill can be considered to be semi-aerobic, and a higher portion of the degraded organic carbon will convert to carbon dioxide rather than methane. Based on current data, it is estimated that approximately three-quarters of landfilled waste in South Africa enters well managed, sanitary landfills, while the remaining landfilled waste is disposed enters, unsanitary, semi-aerobic landfill sites (DEA 2016, 2018; Rodseth, Notten, and von Blottnitz 2020; WWF SA 2020; DEFF 2022).

The total potential degradable organic carbon (Potential DDOC) prevented from reaching landfill due to the recovery of surplus food was estimated by multiplying the surplus food tonnage by the average decomposable DOC content of food waste and South African landfill's methane correction factor (MCF) (Equation 8). First-Order Decay kinetics were utilised to estimate the degradable organic carbon fraction of food waste that decomposes within a 100-year period (i.e. calculate DDOC decomposed from Potential DDOC). With the quantity of methane avoided estimated by taking into account the fraction of DOC reporting to the leachate stream and the fraction of carbon in landfill gas that is methane (Equation 9). Actual methane releases were estimated multiplying together the methane generation avoided and the fraction of methane not oxidised (Equation 10). The carbon dioxide equivalent emissions were then calculated by multiplying the methane emissions by the methane global warming potential (GWP) (Equation 11). The factors used in the above equations are given in Table 3.

$$Potential\ DDOC\ (tonnes) = Food\ quantity\ (tonnes) \times Food\ DOC\ fraction\ that\ can\ decompose\ (\%) \times MCF\ (\%) \qquad 8$$

$$CH_4\ generation\ avoided\ (tonnes) = DDOC\ decomposed\ (tonnes) \times \left(1 - D_{Leachate}(\%)\right) \times Fraction\ of\ C\ that\ is\ CH_4(\%) \times \frac{16}{12} \qquad 9$$

$$CH_4\ emissions\ avoided\ (tonnes) = CH_4\ generation\ avoided\ (tonnes) \times (1 - MOF(\%)) \qquad 10$$

$$Emissions\ (tonnes\ CO_2e) = CH_4\ emissions\ avoided\ (tonnes) \times Global\ warming\ potential\ (\frac{tonnes\ CO_2e}{tonnes\ CH_4}) \qquad 11$$

Table 3: Factors for the estimation of food waste degradation emissions

Constant	Value	Reference
Degradable organic carbon (DOC) fraction that can decompose	10.1%	(IPCC 2019)
Methane correction factor (MCF)	95%	(IPCC 2019), with SA landfill characteristics split
DOC dissimilated as leachate ($D_{Leachate}$)	2%	(Friedrich and Trois 2013)
Fraction of C that is CH_4 in landfill gas	55%	(Friedrich and Trois 2013)
Methane oxidation factor (MOF)	0%	(IPCC 2019)
Methane GWP	28 kg CO_2e / kg CH_4	(Myhre *et al.* 2013)

3.4 Transport and warehouse operation emissions

To calculate the change in transport and warehouse operation emissions it is necessary to calculate emissions for a "without FoodForward SA" scenario (T_A) and for a "with FoodForward SA" scenario (T_B, T_C, T_D and FFSA) (see Figure 1 for definitions of T_A, T_B, T_C and T_D.) Fuel spend data was used to calculate the emissions associated with T_B, while average vehicle emission factors were used to calculate emissions associated with T_A, T_C and T_D. Warehouse operational emissions were calculated based on electricity spend data.

3.4.1 Calculation of emissions based on fuel spend

Annual fuel spend data was converted to the diesel consumption (litres) based on South Africa's average diesel price for each year (Equation 12). As fuel spend is recorded per financial year, data was only available until the end of February 2022. Therefore, total fuel consumption for 2022 was estimated based on 2021 data for the litres of diesel utilised per tonne of food saved through the Warehouse FoodBanking programme and 2022 Warehouse tonnages. The transport emissions were then calculated by multiplying diesel use by the diesel emission factor (Equation 13). The factors used in the above equations are given in Table 4.

$$Diesel\ usage\ (L) = \frac{Fuel\ spend\ (R)}{Average\ diesel\ price\ (\frac{R}{L})} \quad 12$$

$$Diesel\ emissions\ (kg\ CO_2e) = Diesel\ usage\ (L)\ \times\ Diesel\ EF\ (\frac{kg\ CO_2e}{L}) \quad 13$$

Table 4: Factors for the estimation of transport emissions from fuel spend

Constant	Units	Value	Reference
Average diesel price	R / L	2019: R14.15 2020: R12.61 2021: R14.83 2022: R22.03	(SAPIA 2022)
Diesel emission factor	kg CO_2e / L	2.87	(DEA 2017; IPCC 2019)

3.4.2 *Calculation of other transport emissions*

Details of how the beneficiary organisations transport food were not known. Therefore, various assumptions are required for the calculation of these transport emissions, as presented in Table 5.

Table 5: Assumptions for the estimation of transport emissions

Variable	Assumption	Reason
T_A – Vehicle type	Average petrol passenger vehicle	Assumed NPOs do not have access to delivery vehicle
T_A – Distance from retailer to NPO	5 km	Product Environmental Footprint Category Rules default value for retail to consumer transport (European Commission 2018)
T_A – Mass of food transported per trip	100 kg	
T_C – Vehicle type	Average petrol passenger vehicle	As for T_A.
T_C – Distance from FoodForward SA warehouse to NPO	5 km	Product Environmental Footprint Category Rules default value for retail to consumer transport (European Commission 2018)
T_C – Mass of food transported per trip	100 kg	
T_D – Vehicle type	Average petrol passenger vehicle	As for T_A.
T_D – Distance from retailer to NPO	5 km	Product Environmental Footprint Category Rules default value for retail to consumer transport (European Commission 2018)
T_D – Mass of food transported per trip	100 kg	

The number of trips required for each transport segment was estimated by dividing the total quantity of food transported by the mass of food transported per trip (Equation 14). The total annual travel distance was then estimated by multiplying the number of trips by the total distance of the return trip. The return trip distance was assumed to be double the distance of the NPO to the retailer/warehouse (i.e. a dedicated return trip) (Equation 15). Emissions associated with travel were then calculated by multiplying the total annual travel distance by the vehicle emission factor (Equation 16).

$$Number\ of\ trips = \frac{Food\ quantity\ (kg)}{Food\ transported\ per\ trip\ (kg)} \quad 14$$

$$Annual\ distance\ (km) = Numberof\ trips\ \times\ 2 \times\ Distance\ from\ NPO\ to\ retailer\ or\ warehouse\ (km) \quad 15$$

$$Travel\ emissions\ (kg\ CO_2e) = Annual\ distance\ (km) \times Emission\ factor\ (\frac{kg\ CO_2e}{km}) \quad 16$$

The average petrol passenger car emits 0.17 kg CO_2e per km according to the UK Government GHG conversion factors (DEFRA 2021). Due to a lack of South African specific data this emission factor was used as the emission factor for Equation 16.

3.4.3 Calculation of warehouse operation emissions

Annual electricity spend data was converted to the electricity consumption (kWh) based on Eskom BusinessRate electricity pricing for each year (Equation 17). As electricity spend is recorded per financial year, data was only available until the end of February 2022. Therefore, total electricity consumption for 2022 was estimated based on 2021 data for the kilowatt-hours of electricity consumed per tonne of food saved through the Warehouse FoodBanking programme and 2022 Warehouse tonnages. The warehouse operational emissions were then calculated by multiplying electricity consumption by the grid electricity emission factor (Equation 18). The factors used in the above equations are given in Table 6.

$$Electricity\ consumption\ (kWh) = \frac{Electricity\ spend\ (R) - Fixed\ charges\ per\ installation\ (R) \times Numberof\ FoodForward\ SA\ locations}{Electricity\ consumption\ price\ (\frac{R}{kWh})} \quad 17$$

$$Electricity\ emissions\ (kg\ CO_2e) = Electricity\ consumption\ (kWh) \times\ Grid\ electricity\ EF\ (\frac{kg\ CO_2e}{kWh}) \quad 18$$

Table 6: Factors for the estimation of warehouse operation emissions from electricity spend

Constant	Units	Value	Reference
Electricity fixed charges per installation	R / installation	2019: R17,778.24 2020: R19,355.04 2021: R22,298.76 2022: R24,671.26	(Eskom 2022)
Number of installations	number	9	
Electricity consumption price	R / kWh	2019: R1.51 2020: R1.64 2021: R1.89 2022: R2.09	(Eskom 2022)
Electricity emission factor	kg CO_2e / kWh	2019: 0.95 2020: 0.93 2021: 0.95 2022: 0.95	(NBI 2013; DoE 2020; Eskom 2021)

3.4.4 Difference in transport and warehouse operation emissions in the two scenarios

The additional GHG emissions released due to FoodForward SA operations was calculated by subtracting the emissions for the "without FoodForward SA" scenario from those in the "with FoodForward SA" scenario, as shown by Equation 19.

$$Difference\ in\ transport\ and\ warehouse\ operation\ emissions\ (kg\ CO_2e) = (T_B + T_C + T_D + FFSA)(kg\ CO_2e) - (T_A)(kg\ CO_2e) \quad 19$$

4 RESULTS

Overall FoodForward SA operations between March 2019 and December 2022 are estimated to have saved **409,025 tonnes CO_2e.**

- For every tonne of food recovered 5.2 tonnes of greenhouse emissions are saved;
- Annual emission savings are equivalent to the emissions of over 88,000 passenger vehicles driven for a year[1];
- Annual emission savings are equivalent to the emissions associated with the annual electricity usage of approximately 135,000 South African households[2].

Almost two-thirds (62%) of emissions savings are associated with cradle-to-retail food production emissions, with the remainder primarily associated with avoided landfill disposal of food (see Figure 2). The net transport emissions associated with FoodForward SA operations reduce the savings by less than 1% and can thus be considered

[1] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results
[2] Using an average annual electricity consumption of 3,216 kWh per electrified household in South Africa (https://wec-indicators.enerdata.net/household-electricity-use.html#/household-electricity-use.html)

negligible. The estimated emission reductions due to FoodForward SA operations are presented in Table 7, with the emissions released due to FoodForward SA operations presented in Table 8.

Table 7: Emission reductions due to FoodForward SA operations

Emission source	Emissions saved (tonnes CO_2e)
Cradle-to-retail emissions saved	256,466
Disposal emissions saved	154,474
Transport from retail to NPOs without FoodForward SA (T_A)	1,350
TOTAL	412,291

Table 8: Emissions released due to FoodForward SA operations

Emission source	Emissions released (tonnes CO_2e)
Warehouse operational emissions	1,072
Transport from retailers to warehouses (T_B)	844
Transport from FF warehouses to charities (T_C)	880
Transport in FoodShare operations (T_D)	471
TOTAL	3,266

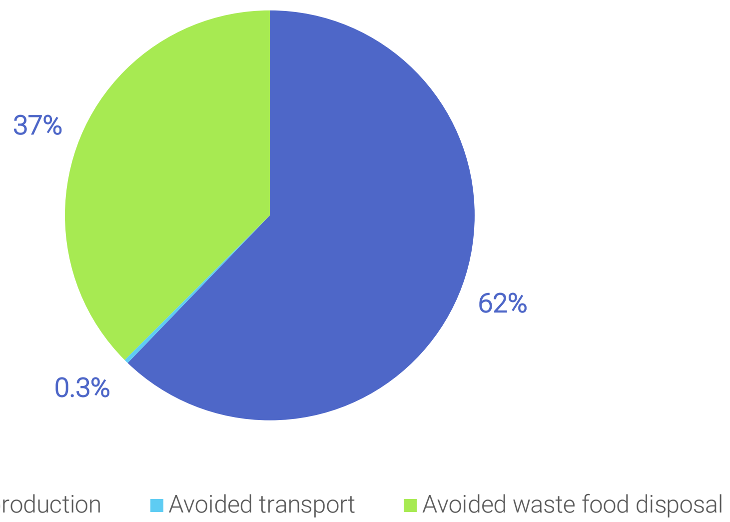

Figure 2: Relative shares of GHG savings

The year-on-year emissions savings achieved is shown in Figure 3, with data labels showing the annual emission savings in tonnes of carbon dioxide-equivalents (tonnes CO_2e). Historically the majority of food savings, and likewise GHG emission savings, have been achieved under the Warehouse FoodBanking programme. This is seen in the 2019 to 2021 data, where between 10% and 20% of both food saving tonnages and GHG emission savings have been due to Warehouse FoodBanking. This changed in 2022, where over 50% of food savings have been through the FoodShare programme, resulting in over 55% of GHG emission savings likewise being attributed to the FoodShare programme (Figure 4).

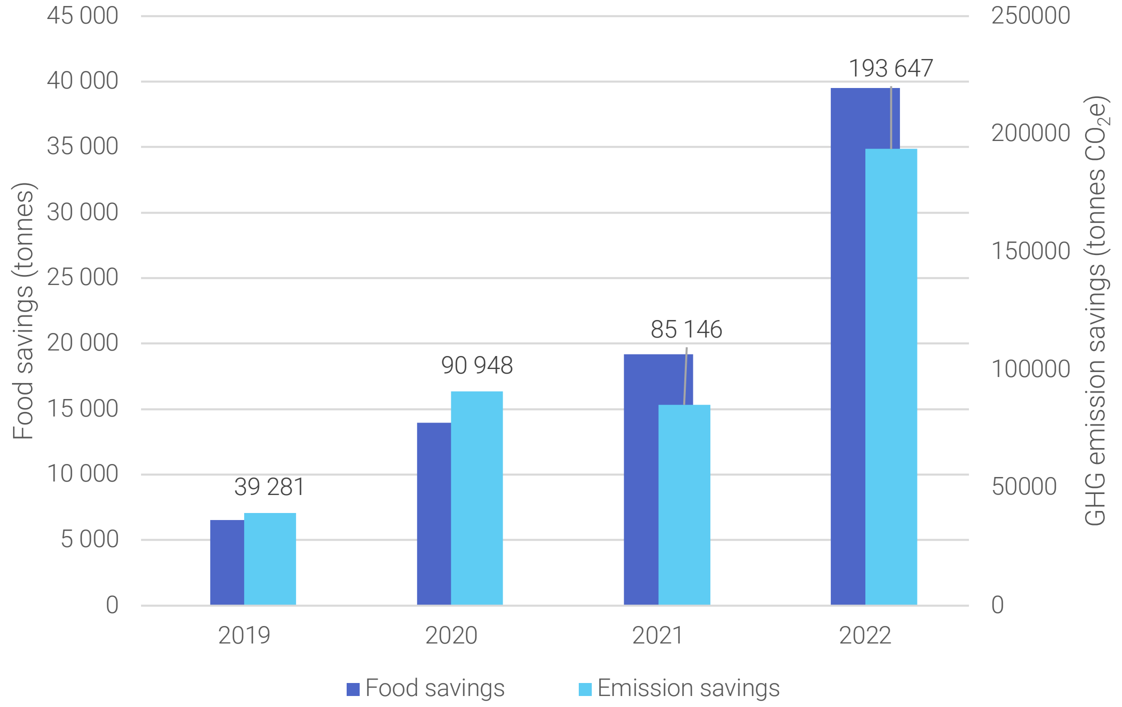

Figure 3: Year-on-year savings achieved

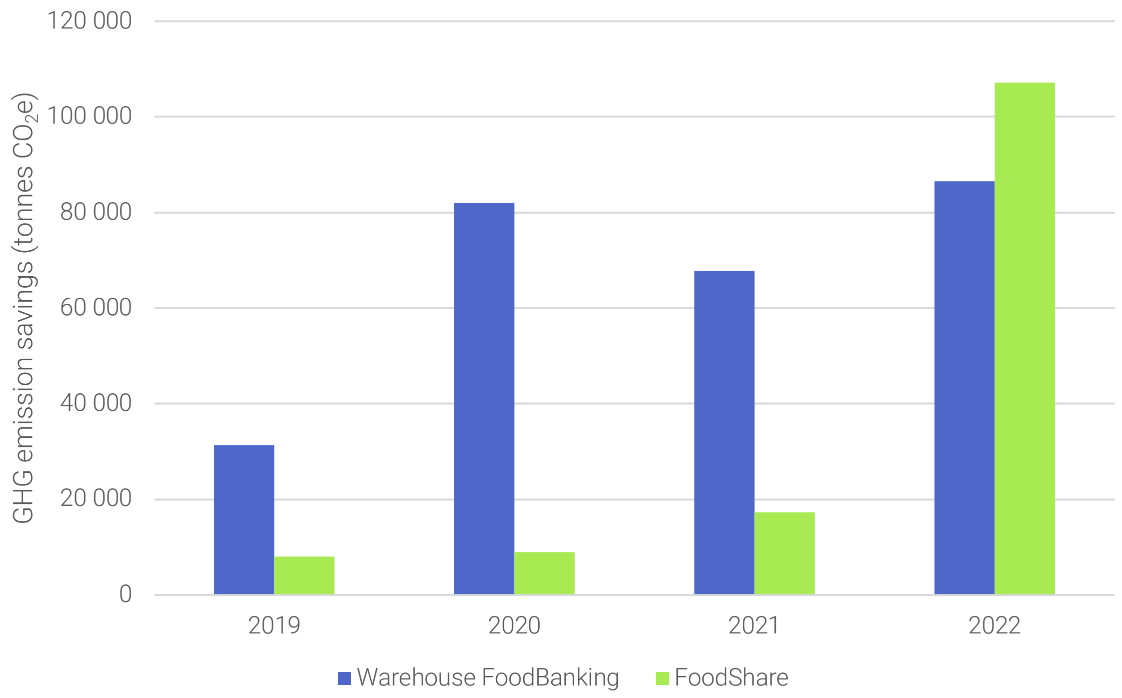

Figure 4: Year-on-year savings achieved per programme

Key assumptions driving the results are that **food that has been donated would otherwise have been disposed of to landfill**, and furthermore, that **landfilled food waste primarily enters managed sanitary landfills**. These assumptions are key because they govern the quantity of methane that would have been emitted as the food degrades, with methane a significantly more potent GHG than carbon dioxide.

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