Life Cycle Assessment of Edible Food Rescue

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DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.

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Foreword

Food waste contributes significantly to climate change, and the Oregon Department of Environmental Quality is committed to reducing that impact. It has been estimated that 20 to 40 percent of all food produced goes uneaten, squandering important resources—such as water, energy, land, fertilizer, and labor—and generating greenhouse gases at every stage.

There is wide acceptance that edible food rescue – recovering surplus food and redistributing it to food insecure people – is a powerful solution for social, environmental, and economic issues related to both food waste and food insecurity. Food rescue is seen as a way to bridge the gap between excess and access. In some cases, keeping food out of landfills has become a justification for rescuing all surplus food regardless of its nutritional value, cost or other environmental impacts. However, not all food rescue is created equal—its benefits and burdens vary widely depending on many factors, including the source, quality and type of food, how it is rescued and redistributed, how much it costs the hunger relief sector to recover, and how much goes uneaten in the end.

As an agency charged with protecting Oregon's air, land and water, DEQ created this report to understand the benefits and tradeoffs of food rescue through an environmental lens. However, environmental impacts are not the only factors that should be considered when developing or deciding whether to pursue food rescue. This report will add to the important conversations about when and how to rescue surplus food, with both people and the planet in mind. We recognize that hunger is a complex issue, and we commend the many organizations working to eliminate hunger in Oregon and build healthy communities.

Executive Summary

The Materials Management program at the Oregon Department of Environmental Quality envisions that in 2050, Oregonians produce and use materials responsibly—conserving resources, protecting the environment and living well. To achieve this vision, our work examines the life cycle environmental impacts of all types of materials and products. One important material, both in terms of its environmental impact and connection to well-being, is food. DEQ has developed a Strategic Plan for Preventing the Wasting of Food specifically to address the scale of this problem. With this strategic plan, DEQ aims to change the conversation from a focus on managing food waste to preventing wasted food in the first place.

To date, discussion around the impacts of food has been motivated by the idea that we must keep wasted food out of landfills, either by rescuing surplus food or through collection for other uses such as compost and energy production. This underlying motivation to keep food from going into landfills, though well intentioned, contributes to a common belief that food rescue is a good idea at all costs. This belief can lead to donation of food that, to quote one food bank, is “not fit to be rescued.”

The primary goal of this study was to calculate the environmental impacts of various food rescue scenarios and understand the trade-offs both across these scenarios and across environmental impact categories. As a secondary objective, the study sought to determine the relative magnitude of food rescue activities to the overall life cycle impacts of food. This study is not intended to provide absolute direction on when it is advisable to rescue food; rather, it is intended to help inform decision-making by food rescue organizations and their donors. Where nutritious, high quality food can be rescued in a manner that is effective for food rescue organizations and their clients, it should be rescued. At the same time, there may be cases where the value of surplus food does not justify the environmental impacts that rescuing it will incur.

Results can be used by various stakeholders to understand the relative trade-offs of different methods of food rescue. Participants in the food rescue system, such as food banks, food pantries, and non-profits, are the primary intended audience for this analysis. However, other actors in the food rescue system, such as local or regional governments enacting policies to divert food waste from landfills, might also learn from these results.

While this study follows the ISO 14040/14044 standards regarding guidelines and methodology for conducting an LCA, it has not undergone third-party critical review.

Key Findings

Through our environmental analysis, we found that it is not always environmentally beneficial to rescue food. Sometimes the emissions associated with all rescue activities outweigh the benefits of avoiding the food entering the landfill or compost facility.

A summary of the key findings is below.

- The amount of rescued food that ends up being wasted anyway – both at the rescue organization and by the recipient – is a significant driver of overall life cycle impacts.
- The mode and distance of transport also matter significantly to the final impact results. The least efficient means of transporting rescued food was by passenger vehicle.
- Diverting food from landfills provides environmental benefits; however the magnitude of those benefits must be considered along with the impacts of food rescue activities. In some cases, the impacts of food rescue activities exceed the benefits of diverting food from landfill.

- The impacts of facilities and operations associated with rescue were consistently a small contributor to the overall lifecycle impacts of rescued food.
- End-of-life disposition (landfill, aerobic composting, incineration, or anaerobic digestion) of food that is lost or wasted was often a small contributor to life cycle impacts across all categories. However, it became meaningful for instances where loss or waste rates were high.
- When including the upstream production of food and distribution, the relevance of food rescue becomes minimal. Upstream production dominates the life cycle impacts.

Conclusions and Recommendations

Some general recommendations emerged from the key findings and a recognition that food rescue, while sometimes playing an important role as an interim solution to hunger, is not always a logical choice from an environmental standpoint.

1. As a general rule, it is best to start with preventing wasted food, also known as source reduction, when considering higher order goals related to environmental and social outcomes (see p.16 for an image of the wasted food hierarchy). Preventing the loss or wasting of food in the first place avoids environmental impacts before they happen.
2. When rescuing food, target foods that have higher nutritional value and are most likely to be consumed. Rescuing every potentially edible food item that might otherwise be wasted leads to increased environmental impacts for the secondary food system, and directs less nutritious food to hunger relief agencies.
3. Rescue foods using the most efficient mode of transport and from as close to recipients as possible.
    - Transporting food in personal motor vehicles, like cars, proved to be the least efficient, and most impactful, means of rescue.
    - To a lesser degree, traveling long distances to rescue food also increased the impacts of food rescue, even if done with a relatively efficient means of cargo transport.

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Acronyms and Abbreviations

ADP	Abiotic Depletion Potential
AP	Acidification Potential
AWARE	Available Water Remaining Methodology
DEQ	Oregon Department of Environmental Quality
ELCD	European Life Cycle Database
EoL	End of life
EP	Eutrophication Potential
GHG	Greenhouse Gas
GTP	Global Temperature Potential
GWP	Global Warming Potential
ILCD	International reference Life Cycle Data system
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
NMVOC	Non-methane Volatile Organic Compound
NOx	Nitrogen Oxides
ODP	Ozone Depletion Potential
PED	Primary Energy Demand
POCP	Photochemical Ozone Creation Potential
SFP	Smog Formation Potential
SOx	Sulfur Oxides
TRACI	Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts
VOC	Volatile Organic Compound

Glossary of Terms

Avoided burden approach

A method of recycling allocation, also referred to as system expansion, 0/100, or End-of-life recycling, whereby a share of the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. The result is an environmental credit at end of life.

Allocation

"Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems" (ISO 14040:2006, section 3.17).

Background (secondary) data

Data taken from generic or average life cycle inventories for the energy and materials. Can be upstream or downstream in the life cycle. The opposite of primary data.

Background system

"Those processes, where due to the averaging effect across the suppliers, a homogenous market with average (or equivalent, generic data) can be assumed to appropriately represent the respective process … and/or those processes that are operated as part of the system but that are not under direct control or decisive influence of the producer of the good…." (JRC 2010, pp. 97-98) As a general rule, secondary data are appropriate for the background system, particularly where primary data are difficult to collect.

Closed-loop and open-loop allocation of recycled material

"An open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties."

"A closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials." (ISO 14044:2006, section 4.3.4.3.3).

Co-products

"Any of two or more products coming from the same unit process or product system." (ISO 14040:2006, section 3.10).

Cradle-to-gate

System boundary delineation from raw material extraction through to the so-called "gate" of the manufacturing facility, including upstream energy and material production, all associated transport, and on-site manufacturing.

Cradle-to-grave

System boundary delineation covering the entire product life cycle, from raw material extraction to end of life. This generally includes everything in the cradle-to-gate system boundaries plus the installation, use, and EoL disposition (e.g., landfill, recycling, composting, or incineration) stages of the product or system.

Cradle-to-cradle

A system boundary delineation that is the same as cradle-to-grave, but implies a specific fate (reuse or recycling) at end of life.

Cut-off approach

A method of recycling allocation in which the burden of the primary production is attributed to the first life cycle and the burden associated with secondary material recovery and refining is attributed to the subsequent life cycle.

Edible food rescue

Redistributing edible food that would otherwise go unharvested or be discarded. Sometimes referred to as *food rescue* or *donation*.

Food Recovery

Managing discarded food through, for example, composting or anaerobic digestion.

Foreground system

"Those processes of the system that are specific to it … and/or directly affected by decisions analyzed in the study." (JRC 2010, p. 97) This typically includes first-tier suppliers, the manufacturer itself and any downstream life cycle stages where the manufacturer can exert significant influence. As a general rule, specific (primary) data should be used for the foreground system.

Functional unit

"Quantified performance of a product system for use as a reference unit" (ISO 14040:2006, section 3.20).

Gate-to-grave

System boundary delineation covering one or more processes through to end of life. While the initial gate can vary, this generally includes everything after the cradle-to-gate boundary such as use, maintenance, and EoL disposition (e.g., landfill, recycling, composting, or incineration) stages of the product or system.

Human health endpoint

Disease symptom or related marker of a health impact on a human or other being, e.g., cancer or reproductive toxicity.

Healthy, Nutritious Food

A variety of foods from each food group, including items that can be used together to create complete meals. Includes items that are low in sodium, sugar and saturated/trans-unsaturated fats, as well as fruits and vegetables, whole grains, lean protein, and low-fat dairy products.

Impact assessment category

A "class representing environmental issues of concern to which life cycle inventory analysis results may be assigned." (ISO 14040:2006, section 3.39).

Life cycle

A holistic view of a product or system as “consecutive and interlinked stages … from raw material acquisition or generation from natural resources to final disposal” (ISO 14040:2006, section 3.1).

Life Cycle Assessment (LCA)

“Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle” (ISO 14040:2006, section 3.2).

Life Cycle Inventory (LCI)

“Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle” (ISO 14040:2006, section 3.3).

Life Cycle Impact Assessment (LCIA)

“Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product” (ISO 14040:2006, section 3.4).

Life cycle interpretation

“Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations” (ISO 14040:2006, section 3.5).

Lost food

Rescued food that is lost (enters end-of-life disposition) prior to the point of being given to humans. Can be due to causes such as spoilage, damage, or food safety concerns. Lost food is a subset of *wasted food* specifically related to food entering end-of-life disposition during food rescue activities

Partner agency

This term is commonly used by the Oregon Food Bank to describe food pantries or similar local food donation sites, often abbreviated as PA.

Primary data

Data collected directly from a manufacturer, producer, vendor, or process operators often through process flow diagrams, financial or emissions reporting data, equipment specifications, or bills of material.

Prepared food

Food sold in a heated state or heated by the seller, or two or more food ingredients mixed or combined by the seller for sale as a single item, but not including food that is only cut, repackaged, or pasteurized by the seller. (Excerpted from the State of New Jersey Technical Bulletin 71, 2013).

Sunk Costs

Commonly used in economics to refer to a cost or expenditure that has already been incurred and cannot be recovered. Herein we use this term to refer to the upstream life cycle environmental impacts (costs) associated with the conventional supply chain for food (e.g., production, distribution, storage, retail).

Wasted food

Discarded food that is otherwise edible for human consumption. Can be due to various causes such as spoilage, damage, food safety concerns, date labeling, individual preference, ability to cook, or knowledge of preparation. Distinct from *lost food* in that wasted food can occur any point across the life cycle (e.g. at the farm or in the home).

Wasted food prevention

Avoiding the wasting of food in the first place.

1. Background

DEQ's Strategic Plan for Preventing the Wasting of Food (Oregon DEQ, State of Oregon: Materials Management, 2017) identifies nine priority projects to be carried out over the next five years. This LCA study is a component of one of those projects (specifically Project 6a), focusing on the environmental impacts related to food rescue.

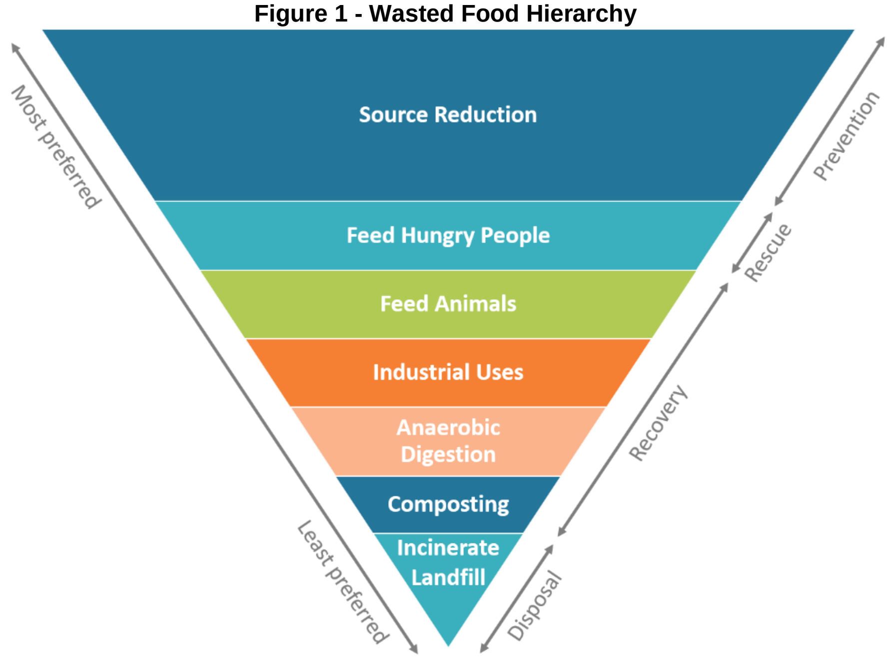
The term "edible food rescue" is used to refer to a suite of actions that redistribute food from upstream in the value chain (farms, manufacturers, retailers, restaurants) to other locations where it can be provided to individuals who are food insecure. Such food is intended for human consumption but for a variety of reasons (aesthetics, size, overproduction, etc.) goes unsold or is unlikely to sell before it goes bad. There is wide acceptance that edible food rescue is a powerful solution for social, environmental, and economic issues related to both food waste and food insecurity. In fact, laws have been enacted at the federal (and state) level that provide tax benefits (ORS 315.156, 2014); (26 U.S. Code § 170(e)(3)(C), 2015) and limitations of liability (42 U.S. Code § 1791, 1996) to encourage food donation/rescue to non-profits.[i] And rightfully so. In the United States, 13.7 percent of households (nearly 17 million) face food insecurity and here in Oregon the rate of food insecurity is higher than the national average at 16.1 percent (Coleman-Jensen, Rabbitt, Gregory, & Singh, 2016).

This study is not intended to challenge the need for or importance of food rescue, or the reality and scale of food insecurity. However, not all edible food rescue is the same. From a nutritional perspective, rescuing and redistributing fresh vegetables and other nutrient-rich foods is highly desirable. However, just like conventionally purchased food, these donated foods are sometimes discarded, uneaten, by the recipients. Alternatively, sources of food such as grocers and restaurants donate foods that cannot be redistributed successfully or have poor nutritional quality. Organizations that conduct food rescue typically have as their mission the alleviation of hunger. Yet some food rescue actions yield relatively little food at a higher cost, making such food rescue undesirable: more people could be fed if the money were spent on buying food directly from farms (Miller, Klosterman, & Pearmine, 2017). And from an environmental perspective, edible food rescue can reduce landfill emissions, but these environmental benefits may be offset by energy use and other impacts associated with collection and storage.

The environmental impacts generated within this study are intended to:

- Identify modes of collection and redistribution that are more or less beneficial, relative to each other.
- Whether the environmental benefits of rescue, namely the avoided need to landfill rescued food, fully offset the impacts of the combined rescue activities.
- Develop foundational research to build upon for other materials management projects, related to sustainable consumption and food waste prevention.

Figure 1 - Wasted Food Hierarchy



The results of this LCA study are intended to support an array of stakeholders in understanding the trade-offs of different food rescue systems and optimizing their efforts to minimize food waste, feed the hungry, and reduce environmental impacts. These stakeholders might include:

- Local, state, or federal governments
- Food redistribution organizations
- Industry groups and food manufacturers
- Academia, influencers, or thought leaders

2. Goals of the Study

The primary goal of this LCA study is to quantify the environmental impacts and trade-offs of various edible food rescue pathways, demonstrating the environmental benefits and impacts associated with different types of food rescue activities. In particular, this study seeks to identify the key variables and the circumstances under which these benefits are more or less likely to be realized. Edible food rescue is promoted (CARB, 2017) as a method to mitigate greenhouse gas emissions (primarily landfill methane emissions). This study will explore the magnitude of these potential benefits (and other environmental benefits). The purpose of such an exploration is so that programs and food rescue organizations with a climate or broader environmental mission can prioritize and more beneficially direct their resources.

A secondary goal of this study is to measure the relative magnitude of food rescue impacts in the broader context of the full life cycle of food. The purpose of this secondary goal is to understand just how large of a contributor to overall life cycle impacts is food rescue and similarly what is the magnitude of the benefits of avoided disposal, relative to total life cycle impacts.

3 Scope of the Study

The following sections describe the general scope of the project to achieve the stated goals. This includes, but is not limited to, the identification of specific edible food rescue systems to be assessed, the product function, functional unit and reference flows, the system boundary, allocation procedures, and cut-off criteria of the study.

3.1 Product Systems

The product systems to be studied are different pathways for edible food rescue; the main function of each of these systems are to capture and redistribute food to feed humans. DEQ identified, with the help of Oregon Food Bank, a list of many possible edible food rescue pathways. This list was refined to a representative subset of the most common or emerging edible food rescue pathways in Oregon. The edible food rescue pathways studied are enumerated in Table 1 below, along with a brief description. More details on each individual scenario can be found in Section 4. Life Cycle Inventory Analysis.

Table 1 - Edible Food Rescue Pathways Evaluated

Scenario	Description
S1_07 - Redistribution from Farm, Grower/Packer (OFB)	Large scale produce rescue from farms, based on primary data from Oregon Food Bank, this scenario assumes 7 percent of rescued food is wasted.
S1_14 - Redistribution from Farm, Grower/Packer (OFB)	Large scale produce rescue from farms, based on primary data from Oregon Food Bank, this scenario assumes 14 percent of rescued food is wasted.
S1_20 - Redistribution from Farm, Grower/Packer (OFB)	Large scale produce rescue from farms, based on primary data from Oregon Food Bank, this scenario assumes 20 percent of rescued food is wasted.
S2_07 - Gleaning (SH)	Small to medium scale, regional produce rescue from farms based on gleaning by volunteer crews, based on primary data from Salem Harvest, this scenario assumes 7 percent of rescued food is wasted.
S2_14 - Gleaning (SH)	Small to medium scale, regional produce rescue from farms based on gleaning by volunteer crews, based on primary data from Salem Harvest, this scenario assumes 14 percent of rescued food is wasted.
S2_20 - Gleaning (SH)	Small to medium scale, regional produce rescue from farms based on gleaning by volunteer crews, based on primary data from Salem Harvest, this scenario assumes 20 percent of rescued food is wasted.
S3_07_Car - Gleaning (UG)	Small scale, local car-based rescue of various foods from retailers, backyards, and other businesses, estimated based on minimal primary data from Urban Gleaners, this scenario assumes 7 percent of rescued food is wasted.
S3_14_Car - Gleaning (UG)	Small scale, local car-based rescue of various foods from retailers, backyards, and other businesses, estimated based on minimal primary data from Urban Gleaners, this scenario assumes 14 percent of rescued food is wasted.
S3_20_Car - Gleaning (UG)	Small scale, local car-based rescue of various foods from retailers, backyards, and other businesses, estimated based on minimal primary data from Urban Gleaners, this scenario assumes 20 percent of rescued food is wasted.
S3_07_Van - Gleaning (UG)	Small scale, local van-based rescue of various foods from retailers, backyards, and other businesses, estimated based on minimal primary data from Urban Gleaners, this scenario assumes 7 percent of rescued food is wasted.

S3_14_Van - Gleaning (UG)	Small scale, local van-based rescue of various foods from retailers, backyards, and other businesses, estimated based on minimal primary data from Urban Gleaners, this scenario assumes 14 percent of rescued food is wasted.
S3_20_Van - Gleaning (UG)	Small scale, local van-based rescue of various foods from retailers, backyards, and other businesses, estimated based on minimal primary data from Urban Gleaners, this scenario assumes 20 percent of rescued food is wasted.
S4_07 - Retail Donation to PA (CSC)	Small scale, local food rescue from groceries and other retailers, based on primary data from Clackamas Service Center, this scenario assumes 7 percent of rescued food is wasted.
S4_14 - Retail Donation to PA (CSC)	Small scale, local food rescue from groceries and other retailers, based on primary data from Clackamas Service Center, this scenario assumes 14 percent of rescued food is wasted.
S4_20 - Retail Donation to PA (CSC)	Small scale, local food rescue from groceries and other retailers, based on primary data from Clackamas Service Center, this scenario assumes 20 percent of rescued food is wasted.
S5_07 - Retail Donation to Food Bank (Estimate)	Moderate scale, local/regional food rescue from groceries and other retailers, based on estimates derived from data provided by Clackamas Service Center and Oregon Food Bank's Fresh Alliance program, this scenario assumes 7 percent of rescued food is wasted.
S5_14 - Retail Donation to Food Bank (Estimate)	Moderate scale, local/regional food rescue from groceries and other retailers, based on estimates derived from data provided by Clackamas Service Center and Oregon Food Bank's Fresh Alliance program, this scenario assumes 14 percent of rescued food is wasted.
S5_20 - Retail Donation to Food Bank (Estimate)	Moderate scale, local/regional food rescue from groceries and other retailers, based on estimates derived from data provided by Clackamas Service Center and Oregon Food Bank's Fresh Alliance program, this scenario assumes 20 percent of rescued food is wasted.
S6_07 - Prepared Food from Retail (Estimate)	Small scale, local food rescue from grocers and other retailers, specifically of prepared food items. Estimates derived from data provided by Clackamas Service Center, New Seasons Market, and Oregon Food Bank, this scenario assumes 7 percent of rescued food is wasted.
S6_14 - Prepared Food from Retail (Estimate)	Small scale, local food rescue from grocers and other retailers, specifically of prepared food items. Estimates derived from data provided by Clackamas Service Center, New Seasons Market, and Oregon Food Bank, this scenario assumes 14 percent of rescued food is wasted.
S6_20 - Prepared Food from Retail (Estimate)	Small scale, local food rescue from grocers and other retailers, specifically of prepared food items. Estimates derived from data provided by Clackamas Service Center, New Seasons Market, and Oregon Food Bank, this scenario assumes 20 percent of rescued food is wasted.
S7_07 - Direct Donation of Prepared Food (Estimate)	Micro scale, local food rescue from commercial kitchen, specifically of prepared food items. Estimates derived from interviews with Providence Milwaukie staff. This scenario assumes 7 percent of rescued food is wasted.
S7_14 - Direct Donation of Prepared Food (Estimate)	Micro scale, local food rescue from commercial kitchen, specifically of prepared food items. Estimates derived from interviews with Providence Milwaukie staff. This scenario assumes 14 percent of rescued food is wasted.

S7_20 - Direct Donation of Prepared Food (Estimate)	Micro scale, local food rescue from commercial kitchen, specifically of prepared food items. Estimates derived from interviews with Providence Milwaukie staff. This scenario assumes 20 percent of rescued food is wasted.
S8_07_Car - Local Small Business Food Rescue App (Estimate)	Small scale, local food rescue from retailers, specifically of prepared food items recused by volunteers. Estimates derived on this scenario are based on assumptions and anecdotal information from interviews with food rescue organizations. This scenario assumes 7 percent of rescued food is wasted.
S8_14_Car - Local Small Business Food Rescue App (Estimate)	Small scale, local food rescue from retailers, specifically of prepared food items recused by volunteers. Estimates derived on this scenario are based on assumptions and anecdotal information from interviews with food rescue organizations. This scenario assumes 14 percent of rescued food is wasted.
S8_20_Car - Local Small Business Food Rescue App (Estimate)	Small scale, local food rescue from retailers, specifically of prepared food items recused by volunteers. Estimates derived on this scenario are based on assumptions and anecdotal information from interviews with food rescue organizations. This scenario assumes 20 percent of rescued food is wasted.

The environmental impacts of each individual food rescue pathway are calculated and presented across all the above scenarios. Where possible the models for each rescue pathway are based on primary data obtained from various food rescue organizations. If no primary data on a specific food rescue pathway was obtainable, then literature, existing LCI databases and/or expert judgement were used to define the LCI for a given rescue pathway.

3.2 Functional Unit and Reference Flows

Since the function of the system(s) under consideration is stated as “the rescue of edible food to feed humans” and the goal of the study is to quantify the environmental impacts and trade-offs of different food rescue pathways, the functional unit has been defined <u>1000 kg of rescued food that is consumed</u>. While mass does not fully capture many of the other functions provided by food (e.g., calorific value, nutrient density, social interaction, happiness/pleasure, well-being, etc.) for comparing food rescue pathways, it was determined to be a sufficient metric.

3.3 System Boundary

Figure 2 shows the full life cycle of food and illustrates the points across the life cycle where food waste can occur. The rescue pathways modeled begin at the sources of food waste as shown by the system boundary designation (dotted line). The system boundary for the study begins at the point of rescue, to align with the stated goal, which is to “quantify the environmental impacts of different food rescue systems.” Unlike other life cycle assessments, which typically start at the point of raw material extraction, this study aims to compare the trade-offs of different food rescue pathways from the point at which the food is rescued through to distribution of the food to people. All of the impacts that occur prior to the food rescue are treated as a sunk cost and therefore are not considered in the main body of this study. However, in order to understand the magnitude and relevance of these sunk costs to the broader life cycle of food that ends up in the rescue stream, a sensitivity analysis was performed to include these life cycle stages. These results can be found in Appendix A – Sensitivity Analysis.

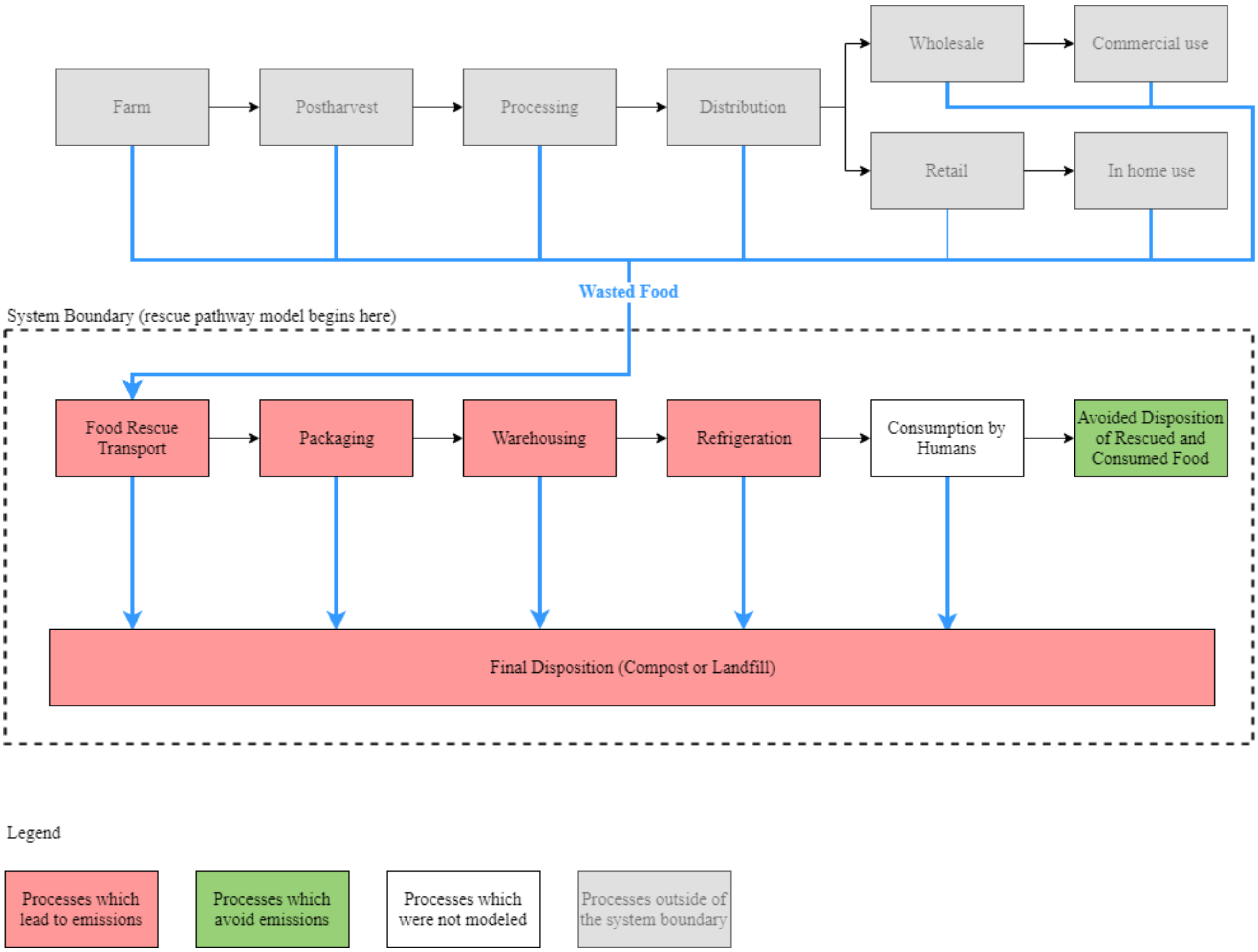


Figure 2 - Sources of wasted food for edible food rescue and study system boundary

For the results presented in the main body of this report, the system boundary includes: all transport from the point of rescue to people, packaging (specifically added for rescue), warehousing, refrigeration, energy/fuel use, any losses/spoilage/scrap throughout, and final disposition. Final disposition includes scenarios where rescued food is either composted or landfilled when not eaten and instead is ultimately wasted. The boundary ends at the point where the food is given to a person and a credit is calculated for the avoided burdens of disposal, which would have occurred, had the food not been rescued. All results show this credit as a separate informational item, meaning that results are shown with and without this credit included.

Of note, food preparation by the rescue organization has been excluded. Some rescued foods are redistributed "as is" while others are reprocessed, for example, into soups or stews. DEQ acknowledges this as a limitation (and discusses this further in Section 3.9). While life cycle assessment generally strives to assess the potential environmental burdens over the full life cycle, the omission of life cycle phases as represented by the chosen system boundary is permissible if the conclusions from the study closely reflect this choice (ISO 14044, section 4.2.3.3.1).

Table 2 - System Boundary

Included	Excluded
✓ Transportation and fuel usage from point of rescue to food rescue organization ✓ Additional packaging materials required for rescue ✓ Disposal of packaging material ✓ Refrigeration of rescued food up to the point of distribution to humans for consumption ✓ Upstream electricity and fuel production ✓ On-site electricity and fuel usage ✓ Any direct air and water emissions ✓ Disposal of rescued food that is not eaten ✓ Avoided burden of composting/landfilling wasted food that is rescued and consumed.	× Upstream production of food × Packaging of food prior to point of rescue × Inbound transportation for process materials × Capital equipment × Personnel transportation × Use phase activities or emissions (e.g., preparation and cooking of rescued food) × Building operational energy use × Building operational water use × Construction and maintenance of capital equipment × Maintenance and operation of support equipment × Human labor and employee commuting × Wastewater treatment of human waste

3.3.1 Time Coverage

Primary data collected for this study are based on fiscal year 2015, which for Oregon Food Bank is July 1, 2015 to June 30, 2016, where possible.

3.3.2 Technology Coverage

This study is intended to represent various food rescue pathways and so the foreground system covers technology related to transportation, refrigeration, warehousing, packaging and disposition (landfilling or composting) of rescued food. The background system includes electricity, thermal energy, energy carriers (e.g., fuels), and materials (packaging, ancillaries).

3.3.3 Geographical Coverage

The study is intended to represent food rescue within the state of Oregon.

3.4 Allocation

When an allocation was necessary (if there was co- or by-product) during the data collection phase, the allocation rule most suitable for the respective product was applied. Allocation of background data (energy and materials) are defined by the source database (GaBi). Specific allocation for materials and energy carriers follows the rules of ISO 14044 section 4.3.4.3.

End-of-life allocation generally follows the requirements of ISO 14044, section 4.3.4.3.

Energy recovery: In cases where materials are sent to waste incineration, they are linked to an inventory that accounts for waste composition and heating value as well as for regional efficiencies and heat-to-power output ratios. Credits are assigned for power outputs using the regional grid mix.
Landfilling: In cases where materials are sent to landfills, they are linked to an inventory that accounts for waste composition, regional leakage rates, landfill gas capture as well as utilization rates (flaring vs. power production).

Composting: In cases where materials are sent to compost, they are linked to an inventory that accounts for waste composition, composting methodology and crediting for avoided emissions.
Avoided burdens: A credit is granted to the system for the avoided burden of waste management for wasted food that is rescued and consumed. This credit is represented by the average mix of final disposition for wasted food in Oregon (described in detail in Section **Error! Reference source not found.**, below).

3.5 Cut-off Criteria

No cut-off criteria are defined for this study. All available energy and material flow data have been included in the model. In cases where no matching life cycle inventories are available to represent a flow, proxy data have been applied based on conservative assumptions regarding environmental impacts. For use of proxy data, see chapter 4.10 Background Data.

3.6 LCIA Methodology and Impact Categories

To fulfill the goal of the project, DEQ has selected the impact assessment categories and other metrics shown in Table 3 and Table 4. Most of the impact assessment categories are based on the TRACI 2.1 impact assessment methodology as its characterization factors are representative of U.S. average conditions.

Global warming potential (GWP), along with primary energy demand (PED), are included because of their particular relevance to climate change and energy efficiency. GWP and PED are interrelated, generally understood by the public, and considered the most important environmental issues facing civilization. The global warming potential impact category is based on the current IPCC characterization factors from the 5th Assessment Report (IPCC, 2013) for a 100-year timeframe (GWP100). According to the latest global guidance from the UNEP/SETAC Life Cycle Initiative, GWP based on a 100-year timeframe is the recommended metric to address shorter-term climate change (Frischknecht & Jolliet, 2016). PED is reported in three separate categories: primary energy from renewable resources (PERT), primary energy from non-renewable resources (PENRT), and primary energy from both non-renewable and renewable resources (PERNRT).

Eutrophication (EP), acidification (AP), and smog formation (SFP) potentials are included as they closely relate to air, land, and water quality, and capture the environmental impacts associated with regulated emissions such as NO_x, SO_x, VOCs, and others.

Ozone depletion potential (ODP) is included because of its high political relevance, which eventually led to the worldwide ban of more active ozone-depleting substances. The phase-out of less active substances is due to be completed by 2030. Current exceptions to this ban exist (e.g., for nuclear power production) and thus the indicator is included for reasons of completeness.

The study does not report impacts related to human health and ecotoxicity. The precision of the current USEtox characterization factors, the best currently available, are within a factor of 100–1,000 for human health and 10–100 for freshwater ecotoxicity (Rosenbaum, et al., 2008). This uncertainty is higher than for the other included impact categories and so the results would be of limited utility.

DEQ has also chosen to include one metric related to water—blue water consumption. Water consumption is just an inventory-based indicator based on the total removal of water from its watershed (through conveyance, evaporation, or evapotranspiration). Water is included because of its high political relevance and importance to life. The UN, which has adopted access to clean water as one of its sustainable development goals, estimates that around 700 million people do not have access to clean drinking water (UN Economic and Social Council, 2016).

Table 3 - Description of Impact Categories Included

Impact Category	Description	Unit	Reference
Global Warming Potential (GWP100)	A measure of greenhouse gas emissions, such as CO_2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health and material welfare.	kg CO_2 equivalent	(Bare, 2011)
Eutrophication Potential (EP)	Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems, increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.	kg N equivalent	(Bare, 2011)
Acidification Potential (AP)	A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H^+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.	kg SO_2 equivalent	(Bare, 2011)
Smog Formation Potential (SFP)	A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O_3), produced by the reaction of VOC and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be injurious to human health and ecosystems and may also damage crops.	kg O_3 equivalent	(Bare, 2011)
Ozone Depletion Potential (ODP)	A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone layer leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants.	kg CFC-11 equivalent	(Bare, 2011)
Human Health Particulate Matter (PM2.5)	A measure of particulate matter releases into the air, these are an indicator of air quality and have implications to the health of humans and other species.	kg PM2.5 equivalent	(Bare, 2011)

Table 4 - Description of Environmental Indicators

Indicator	Description	Unit	Reference
Primary Energy Demand (PED)	A measure of the total amount of primary energy extracted from the earth. PED is expressed in energy demand from non-renewable resources (e.g., petroleum, natural gas, etc.) and energy demand from renewable resources (e.g., hydropower, wind energy, solar, etc.). Efficiencies in energy conversion (e.g., power, heat, steam, etc.) are taken into account.	MJ (lower heating value)	(Guinée, et al., 2002)
Blue Water Consumption	A measure of the net intake and release of fresh water across the life of the product system. Blue water refers to surface and ground water only (excluding rainwater, green water). Water consumption is typically defined as "water removed from, but not returned to the same drainage basin. Water consumption can be because of evaporation, transpiration, product integration or release into a different drainage basin or the sea. Evaporation from reservoirs is considered water consumption." This is not an indicator of environmental impact without the addition of information about regional water availability.	kg of water	(thinkstep, 2016)

It is critical to note that the impact categories represent potentials—they are approximations of environmental impacts that could occur if emissions would follow a specific impact pathway and meet certain conditions in the receiving environment. Additionally, the inventory only captures that fraction of the total environmental burden that corresponds to the functional unit (i.e., the relative approach of LCA). Results are therefore relative expressions only and do not predict actual impacts. Nor do they measure the exceedance of thresholds, safety margins, hazards, or risks.

DEQ has chosen not to include any weighting or grouping scheme, as this would implicitly require a value-based judgement and is not scientifically based (ISO, 2006). Further, since the study is comparing the environmental impacts and trade-offs of different food rescue systems, each impact is reported separately and thus it is not possible to compare different impact categories to each other.

3.7 Interpretation

The primary analysis quantifying the environmental impacts of each rescue pathway will be interpreted on an impact-by-impact basis. These results will be calculated for each individual rescue pathway and comparisons across the pathways will be performed and combined with scenarios for each pathway based on each of the three generic food categories. Final results are provided in graphical form in the body of this report (see Section 5) and in tabular form as separate document (see S2. FoodRescueLCIAResults_AllScenarios_Grouping.xlsx).

The results are interpreted in terms of the contribution of each life cycle and the overall magnitude of net impacts across scenarios.

Table 5 - Sample Matrix of Results for Each Life Cycle Impact Assessment Category

Rescue Scenarios (Food Type)	Avoided Disposal	EoL Loss	EoL Waste	Facilities and Operations	Food Production	Transportation	Sunk Costs	Net

Rescue Pathway 1 (Chicken)								
Rescue Pathway 1 (Milk)								
Rescue Pathway 1 (Apples)								
Rescue Pathway 2 (Chicken)								
Rescue Pathway 2 (Milk)								
Rescue Pathway 2 (Apples)								
…								
Rescue Pathway n								

Note that in situations where no food rescue pathway outperforms all of its alternatives in each of the impact categories, some form of qualitative evaluation (by definition this is a type of "weighting") is necessary to draw conclusions regarding the environmental performance. Since ISO disallows the use of quantitative weighting factors in comparative assertions to be disclosed to the public, the defensibility of this evaluation depends on the expertise of the authors, a full disclosure of assumptions/limitations, and the ability to convey the underlying logic, which led to the final conclusion.

3.8 Data Quality Requirements

The data used to create the inventory model shall be as precise, complete, consistent and representative as possible in order to fulfill the goal and scope of the study.

- Measured primary data is considered to be of the highest precision, followed by calculated and estimated data.
- Completeness is judged based on the completeness of the inputs and outputs per unit process and the completeness of the unit processes themselves. Cut-off criteria apply and were defined in section 3.5.
- Consistency refers to modeling choices and data sources. The goal is to ensure that differences in results occur due to actual differences between product systems, and not due to inconsistencies in modeling choices, data sources, emission factors, or other.
- Representativeness expresses the degree to which the data matches the geographical, temporal, and technological requirements defined in the study's goal and scope.

An evaluation of the data quality with regard to these requirements is provided in Section 6 of this report.

3.9 Assumptions and Limitations

Key assumptions employed in the underlying LCA model are enumerated below:

- The model assumed that rescued food avoids the disposal of that food, unless the rescued food itself is also wasted, and provides a credit for this avoided disposal. This is not a purely attributional approach.
- No displacement of primary production of food is assumed, when rescued food is given to a recipient, as it is unlikely that the recipient would have otherwise purchased food from the marketplace and uncertain what kind of food would be displaced if so.

- The amount of food that ends up being wasted is a highly relevant, but also uncertain, variable. As such, the model generates results for three different plausible waste rates: 7 percent, 14 percent and 20 percent.
- In the same vein, the amount of food that is lost through the rescue chain (see glossary of terms for difference between lost and wasted food) has significant implications on the results. Where available, primary loss data was used, but in some of the scenarios assumptions on the amount of loss were made. Details are disclosed in Section 4 of this report.
- When no primary data was available, the study assumed that food which goes to end-of-life disposal is handled based on the average mix of dispositions for food waste in Oregon. Details on this mix are described in Section 4 of this report.
- Data was provided by a subset of food rescue organizations in Oregon, and so while generally representative, a specific food rescue pathway elsewhere could have different results. So it is assumed that these organizations represent Oregon, but do not necessarily reflect food rescue operations in other states or regions.

Limitations

- Lack of primary data from food rescue organizations. Not all of the food rescue organizations that participated in the project and provided data had access to all of the data DEQ requested. For example, most organizations had and provided data on the mass of food rescued during the study period, but details on the specific distance and mode of transport to rescue that food, were often unavailable. Additionally, not all organizations tracked the amount of food loss that occurred across their rescue activities. None of the organizations had primary data on the percent of food that ended up being wasted by the recipient.
- The study selected three random food items for the sensitivity analysis and yet these food items are not likely, or even possible, to necessarily rescue through each of the pathways modeled.
- Food preparation, which might take place at the food rescue organizations, has been excluded and assumed to be identical across all scenarios.
- For the sensitivity analysis, the study estimates that the upstream production using secondary life cycle inventories and the distribution/warehousing of food using the primary data collected for rescue as a proxy. For example, the average transportation data obtained from Oregon Food Bank for farm-based food rescue was used to estimate the average transportation sunk cost in a scenario where the point of rescue occurs later in the supply chain, such as at the grocer or retailer.
- The study uses mass as the metric of quantification for the functional unit, but this doesn't fully reflect the function of food, such as nutrient density or economics of each rescue pathway.
- The study did not test the relevance of different end-of-life dispositions for wasted food. For example, if wasted food was sent exclusively to composting. Instead, as noted above, the study assumed the same average mix of dispositions for food waste in Oregon.

3.10 Software and Database

The LCA model and associated Life Cycle Inventory (LCI) were developed using the GaBi ts Software system. GaBi is developed and maintained by thinkstep AG. The GaBi (Service Pack 34, Version 6.115) and Ecoinvent (v3.3) databases were used for life cycle inventory data of raw materials and processes.

3.11 Critical Review

A third-party critical review is required to make any comparative assertions and to ensure consistency between the study and International Standards. However, limitations in the accessibility of primary data on food rescue pathways led DEQ to adjust the goal and scope of the study and to not conduct a third-party critical review. The study still underwent internal quality assurance. However, it should be noted that the results presented herein have not been reviewed by a third party and to the extent possible DEQ has avoided asserting environmental superiority of a given scenario.

4. Life Cycle Inventory Analysis

For each food rescue pathway evaluated, an underlying LCI had to be developed. This section describes the general procedure for data collection and provides a detailed description of the foreground data, inputs, and assumption for each food rescue pathway.

4.1 Data Collection Procedure

Primary data were collected from participating stakeholders using a standardized data collection template. Each template was reviewed for completeness and plausibility using mass balance. If gaps, outliers, or other inconsistencies occurred, DEQ engaged with the data provider to resolve any open issues.

4.2 Scenario 1 - Redistribution from Farm (Grower/Packer)

4.2.1 Overview of Life Cycle

This scenario represents one of the largest pathways for food rescue by Oregon Food Bank (OFB), in terms of mass. Food from growers and packing sheds is transported directly to the OFB headquarters in Portland, OR. To be clear the food has already been harvested from the farm and processed in the packing shed, prior to being rescued through this pathway. From there the food is culled, repacked and distributed to a regional food bank (RFB) before being transported to a local food bank (i.e., a partner agency) for distribution to people. The screen capture of the underlying LCI model for this scenario (Figure 3) illustrates the pathway and quantifies the flows across each stage of the life cycle. Subsequent screenshots will look similar, though the underlying parameters like loss and waste rates will be varied, as will the quantities of flows at each stage. Three sub-scenarios are included:

- S1_07 - Redistribution from Grower/Packer (OFB)
- S1_14 - Redistribution from Grower/Packer (OFB)
- S1_20 - Redistribution from Grower/Packer (OFB)

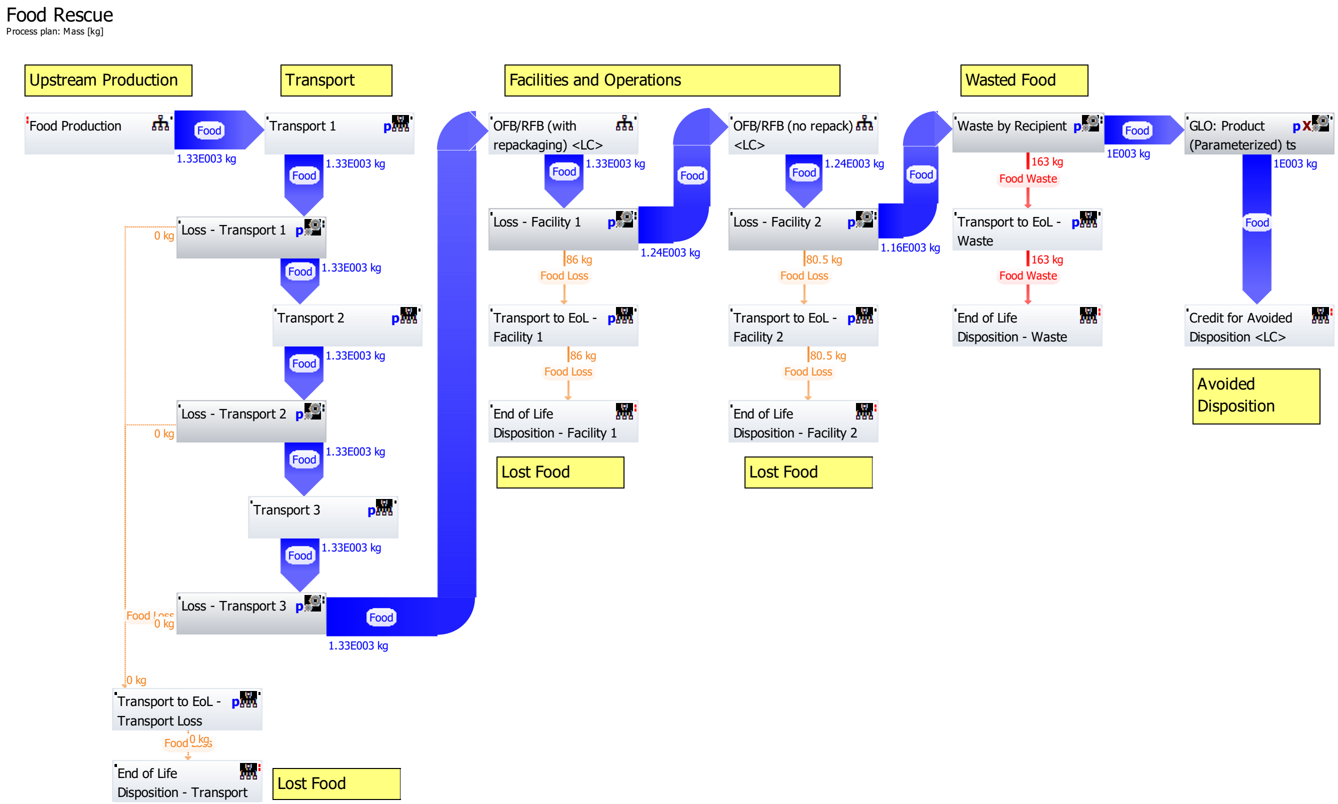


Figure 3 - Model for Food Rescue from Farm with Default Waste/Loss Rates

4.2.2 Description of Process Flow

Each step along the rescue chain for this pathway is described below. Unit process details are shown where primary data was collected and key variables are enumerated.

4.2.2.1 Transport for Food Rescue

Transportation mode and distance is based on data provided by Oregon Food Bank for grower/packer rescue in FY 2015. The distances for legs 1 and 2 reflect the weighted average for all produce from on-farm rescue. The distance for leg 3 was estimated based on the distribution of regional food banks (RFBs) in Oregon and the proximity of partner agencies (PA) to each regional food bank within the statewide network.[1]

Table 6 – Food Rescue Transport Legs by Mode and Distance

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
1	From packing shed to OFB	299.99	Truck - Insulated Refrigerated / 47,000 lb payload - 8b	Thinkstep	2017	US	no
2	From OFB to PA/RFB	138.57	Truck - Insulated Refrigerated / 32,000 lb payload - 8a	Thinkstep	2017	US	no

1 Oregon Food Bank Statewide Network (accessed February 2018) – https://www.oregonfoodbank.org/our-work/partnerships/statewide-network/

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
3	OFB/RFB/PA to PA	30*	Truck - Medium Heavy-duty Diesel Truck / 17,333 lb payload - 6	Thinkstep	2017	US	no

*Estimated based on proximity of facilities (RFB to PA)

4.2.2.2 Receiving and Processing at Food Banks and/or Partner Agencies

For this scenario, it was assumed that food was rescued and passed through two facilities. First through a regional food bank (RFB), where the food was received, sorted and culled, repacked, and stored for redistribution. Second, the food passed through a partner agency (PA) facility; this is a term commonly used by Oregon Food Bank to describe food pantries or similar local food donation sites. At the partner agency facility, the food is received, culled, and stored for redistribution. Losses can occur at either facility and are described further in Section 4.2.2.3.

Table 7 - Inputs and outputs of RFB or PA facility (per 1000 kg of output)

Type	Flow	Value	Unit	DQI
Inputs	Food	1064.8	kg	Measured
	Clamshells (PP)*	0.172	kg	Estimated
	Supersacks (PP)*	0.2756	kg	Estimated
	Mesh Bags (PP)*	0.622	kg	Estimated
	Poly Bags (LDPE)*	0.583	kg	Estimated
	Electricity	58.7	MJ	Measured
	Water (tap)	56.1	kg	Estimated
	Bleach (Sodium Hypochlorite)	0.0113	kg	Estimated
	Corrugated Cardboard	16.936	kg	Estimated
Outputs	Food	1000	kg	Measured
	Loss (Cull)	64.8	kg	Estimated
	Waste Water	56.1113	kg	Calculated
	Plastic Waste on Landfill	1.4326	kg	Calculated
	Cardboard for Reuse	16.936	kg	Calculated
	Supersacks (PP) for Reuse	0.223	kg	Calculated

*for a facility with no sorting and repacking, these flows do not occur.

4.2.2.3 Losses and Waste

Loss occurs at various points along the rescue chain due predominantly to the shelf life of rescued food. Rescued food is brought to a facility where it is sorted and culled. The culling process removes food, which, for various reasons, is deemed unsuitable for recipients. Loss rates were provided by Oregon Food Bank based on FY 2015 operations at their Portland Metro facility. None of the smaller regional food banks and partner agencies that DEQ interviewed maintained records of losses within their facilities. As a result, the data provided by Oregon Food Bank was used to represent loss rates at these other facilities. Finally, it is important to note that the loss rate used for this rescue pathway differ from others, which are based on average loss rate data from Feeding America.

Even with rescued food, waste still occurs at the recipient (consumer) level. However, data on the rate of rescued food that ultimately ends up being wasted was not available. Oregon Food Bank estimated a range and to test the influence of this variable, DEQ calculated the results for the min, max, and average value. Overall results are reported for three different scenarios, varying the percentage of wasted food, for each rescue pathway analyzed.

Table 8 – Loss and Waste Rates

Type	Percent (%)
Loss due to Transport	n/a
Loss at Cull/Sort at Facilities	6.48
Loss at Partner Agency Facilities	6.48
Wasted Food Scenarios	7, 14, 20

4.2.2.4 Transport of Loss and Waste to End of life Disposition

Transportation must also occur when recused food is lost or wasted throughout the rescue chain. Transportation mode and distance for end-of-life disposition of food waste is based both on internal DEQ knowledge of waste haulers in combination with data drawn from the US EPA's WARM Model. There are two legs of transport captured to move lost or wasted food to its final end-of-life disposition. Leg 1 involves regional route pickup and transport to the transfer station; the distance and truck type are based on data obtained from ICF, the developer of the US EPA's WARM model. Leg 2 involves transport from the transfer station to the site of final disposition (e.g., landfill, composting facility, etc.). For Leg 2 the distance is an estimate reflecting the distance from Bend to Portland Metro (selected as the maximal plausible distance that lost or wasted food could travel in Oregon, as validated by internal expert judgement) and the truck type is based again on data obtained from ICF regarding the US EPA's WARM model.

Table 9 – Loss and Wasted Food Transport Legs by Mode and Distance

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
1	Facility loss/recipient waste to transfer station	20	Truck - Medium Heavy-duty Diesel Truck / 17,333 lb payload - 6	Thinkstep	2017	US	no
2	Transfer station to final EoL disposition	162.2	Truck - Heavy Heavy-duty Diesel Truck / 50,000 lb payload -8a	Thinkstep	2017	US	no

4.2.2.5 End of life

Any food that is rescued and not consumed is discarded at end of life. Discarded food can be managed in various ways, the most common of which include landfilling, aerobic composting, anaerobic digestion, or incineration. Other less common treatments such as feeding animals, backyard aerobic composting, or in sink grinding are possible, but have been excluded from this study due to insufficient data on the magnitude of these fates as part of the management of food discards.

In order to derive the mix of end-of-life fates for food that is lost or wasted at various stages of the food rescue life cycle, a mix of primary data was used. For discards originating at the OFB, RFB, or PA facilities, it is assumed that the food is composted (45 percent) and landfilled (55 percent) based on information provided by Oregon Food Bank. For all remaining points across the life cycle where loss or waste occurred, data from Oregon's 2016/2017 Waste Composition Study and 2016 Material Recovery and Waste Generation Survey were used to derive an average estimated mix of disposition for wasted food in Oregon. This estimate does not include food disposed of through in sink grinders, as no available data for this was is measured in the aforementioned studies.

Table 10 – Mix of End-of-life Disposition for Loss and Waste across Life Cycle in Percent (%)

Type	Transport Loss	Facility 1 Loss	Facility 2 Loss	Wasted Food
Anaerobic Digestion	n/a	0	0	3.32
Aerobic Composting	n/a	45.19	45.19	9.76
Incineration	n/a	0	0	4.54
Landfill	n/a	54.81	54.81	82.37

NOTE: This same average mix of dispositions for wasted food in Oregon is used to calculate the credit (informational item) for rescued food that is also consumed (e.g., would have been otherwise destined for end of life).

4.3 Scenario 2 - Gleaning

4.3.1 Overview of Life Cycle

This scenario represents gleaning food at the source. Organizations of varying size and capacity can glean food from commercial farms, orchards, urban trees, community gardens, or even backyard gardens. This scenario is modeled after an organization like Salem Harvest. Under this scenario volunteers travel to a harvest site and hand harvest produce which would otherwise be left on the field. The volunteers retain half of the crop they harvest and the rest is taken to a regional donation site, which could be a food bank or a smaller food pantry. At the donation site, the food is culled, repacked and distributed directly to people. The screen capture of the underlying LCI model for this scenario (Figure 4) illustrates the pathway and quantifies the flows across each stage of the lifecycle. Subsequent screenshots from the GaBi Software tool will look similar, though the underlying parameters like loss and waste rates will be varied, as will the quantities of flows at each stage. Three sub-scenarios are included:

- S2_07 - Gleaning (SH)
- S2_14 - Gleaning (SH)
- S2_20 - Gleaning (SH)

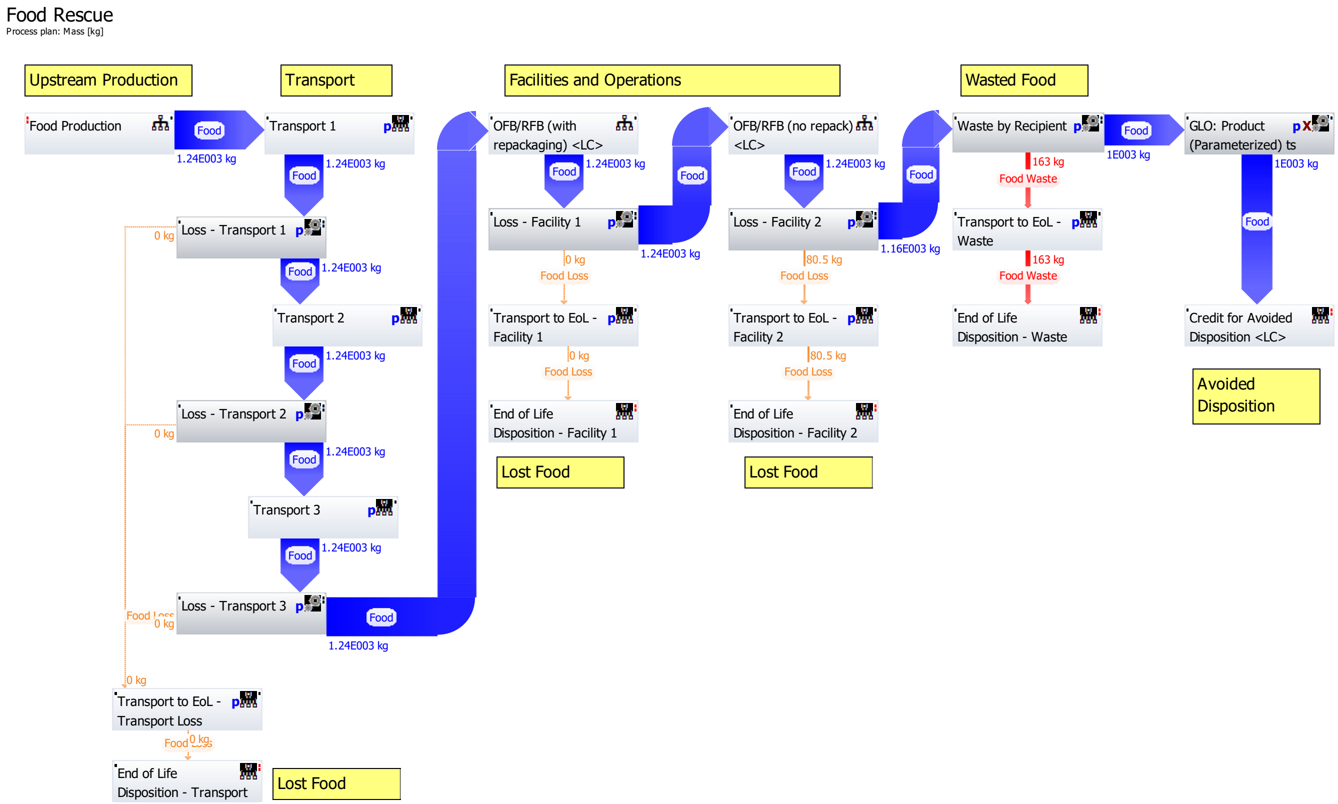


Figure 4 - Model for Food Rescue through Gleaning with Default Waste/Loss Rates

4.3.2 Description of Process Flow

Each step along the rescue chain for this pathway is described below. Unit process details are shown where primary data was collected and key variables are enumerated.

4.3.2.1 Transport for Food Rescue

Transportation mode and distance is based on data provided by Salem Harvest for gleaning in CY 2016. The distances for legs reflect the weighted average for all gleaning rescue. Because most gleaning organizations operate regionally (e.g., Salem Harvest predominantly serves Marion and Polk counties), this scenario assumes that there is no additional transfer of the rescued food between food banks. As in Scenario 1 (Section 4.2) the last leg of transport is the distribution from the donation site to a partner agency (i.e., a food pantry).[2]

Table 11 – Food Rescue Transport Legs by Mode and Distance - Gleaning

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
1	From harvest to donation site	19.8	Truck – Heavy Heavy-duty Diesel Truck / 50,000 lb payload – 8a	thinkstep	2017	US	no

2 Oregon Food Bank Statewide Network (accessed February 2018) - https://www.oregonfoodbank.org/our-work/partnerships/statewide-network/

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
2	From donation site to PA	30*	Truck - Medium Heavy-duty Diesel Truck / 17,333 lb payload - 6	thinkstep	2017	US	no

*Estimated based on proximity of facilities (RFB to PA)

4.3.2.2 Receiving and Processing at Food Banks and/or Partner Agencies

For this scenario, it was assumed that rescued food passed through two facilities. First, a regional foodbank (RFB), where the food is sorted and culled, repacked, and stored for redistribution. Second, the food passed through a partner agency (PA) facility. To model the impacts of receiving and processing at a regional food bank, primary data provided by Oregon Food Bank were used (see Table 7 for LCI) as a proxy. Losses that occur at the facility are described further in Section 4.3.2.3

4.3.2.3 Losses and Waste

See description of losses and waste in Section 4.2.2.3, for loss and waste rates in this scenario see Table 12 below. For this scenario it is assumed that there are no losses at the first cull/sort facility, as the turn-around time from harvest to the regional food bank is short (< 12 hours).

Table 12 – Loss and Waste Rates for Scenario 2 – Gleaning from Field

Type	Percent (%)
Loss due to Transport	n/a
Loss at Cull/Sort at Facilities	0
Loss at Partner Agency Facilities	6.48
Wasted Food Scenarios	7, 14, 20

4.3.2.4 Transport of Loss and Waste to End-of-Life Disposition

Transport of food loss and waste to end-of-life disposition is modeled in the same way as Scenario 1 and is described in Section 4.2.2.4 above.

4.3.2.5 End-of-Life

Management of end-of-life treatments for food discards is modeled in the same way as Scenario 1 (see Section 4.2.2.5 above**Error! Reference source not found.**) with the exception of the assumed fate of food loss that occurs at the receiving facility. Whereas, in Scenario 1 food discards are 100 percent composted, here food discards are managed identically to wasted food.

Table 13 – Mix of End-of-life Disposition for Loss and Waste across Life Cycle in Percent (%)

Type	Transport Loss	Facility 1 Loss	Facility 2 Loss	Wasted Food
Anaerobic Digestion	n/a	3.32	n/a	3.32
Aerobic Composting	n/a	9.76	n/a	9.76
Incineration	n/a	4.54	n/a	4.54
Landfill	n/a	82.37	n/a	82.37

4.4 Scenario 3 – Gleaning (Urban)

4.4.1 Overview of Life Cycle

This scenario represents gleaning food at the source, but unlike the above scenario modeled after a large organization like Salem Harvest, this set of scenarios is based on gleaning performed by individuals or smaller organizations. As DEQ was unable to obtain primary data for this type of food rescue, the underlying model is based on assumptions, which are supported through qualitative interviews with organizations like Urban Gleaners. The key assumptions for this scenario are transport either by passenger car or small van, no repackaging of gleaned food, and direct donation, meaning that rescued food is taken directly to a donation site. Loss rates at the facility are identical to those used in the other gleaning scenario. The screen capture of the underlying LCI model for this scenario (Figure 5 illustrates the pathway and quantifies the flows across each stage of the lifecycle. Subsequent screenshots will look similar, though the underlying parameters like loss and waste rates are varied, as will the quantities of flows at each stage. Six sub-scenarios are included:

- S3_07_Car - Gleaning (UG)
- S3_14_Car - Gleaning (UG)
- S3_20_Car - Gleaning (UG)
- S3_07_Van - Gleaning (UG)
- S3_14_Van - Gleaning (UG)
- S3_20_Van - Gleaning (UG)

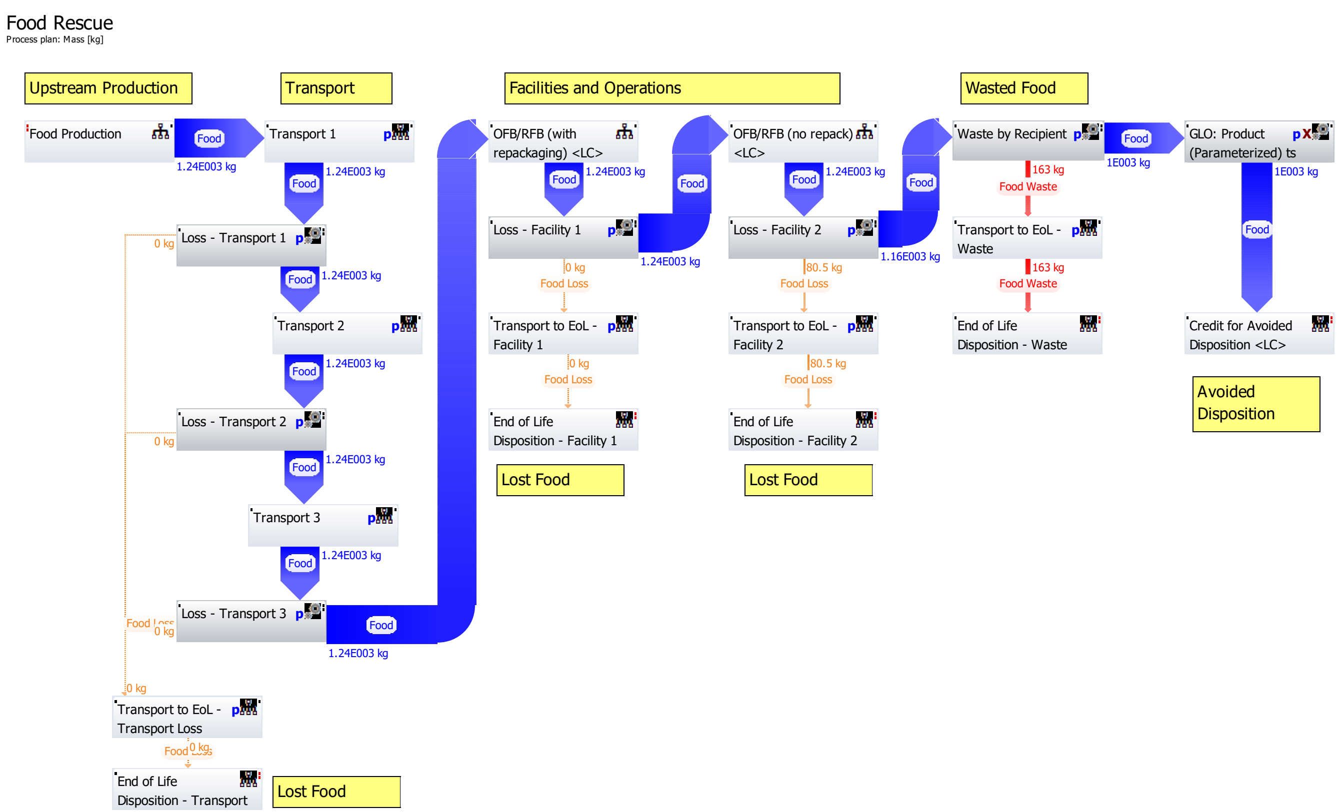


Figure 5 - Model for Food Rescue through Gleaning (Urban) with Default Waste/Loss Rates

4.4.2 Description of Process Flow

Each step along the rescue chain for this pathway is described below. Unit process details are shown where primary data was collected and key variables are enumerated.

4.4.2.1 Transport for Food Rescue

Transportation mode is an estimate of the type of vehicles used for this type of small scale urban gleaning. This estimate is based on anecdotal information obtain through qualitative interviews with Urban Gleaners and observations. Transport distance is an estimate, using the value provided by Salem Harvest for its gleaning operations, which is the calculated weighted average. Because most small gleaning organizations operate locally (e.g., Urban Gleaners operates in the Portland Metro area) there is no additional transfer of the rescued food between food banks.

Table 14 – Food Rescue Transport Leg by Mode and Distance – Gleaning (Urban) either via Car (1a) or Van (1b)

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
1a	From pickup to donation site	19.8	Grocery transport by car	thinkstep	2017	US	No
1b	From pickup to donation site	19.8	Truck – Light Heavy-duty Diesel Truck / 6,667 lb payload – 2b	thinkstep	2017	US	No

4.4.2.2 Receiving and Processing at Food Banks and/or Partner Agencies

For this scenario, it was assumed that rescued food passed through one facility, a small gleaning operation (e.g., Urban Gleaners). At this facility, the rescued food is sorted and culled, repacked, and stored for redistribution, as a proxy for this type of small-scale operation primary data from the operations at Oregon Food Bank were used. Losses that occur at the facility are described further in Section 4.3.2.3

4.4.2.3 Losses and Waste

See description of losses and waste in Section 4.2.2.3, for loss and waste rates in this scenario see Table 15 below.

Table 15 – Loss and Waste Rates for Scenario 3 – Gleaning (Urban)

Type	Percent (%)
Loss due to Transport	n/a
Loss at Cull/Sort at Facilities	6.48
Wasted Food Scenarios	7, 14, 20

4.4.2.4 Transport of Loss and Waste to End-of-Life Disposition

Transport of food loss and waste to end-of-life disposition is modeled in the same way as Scenario 1 and is described in Section 4.2.2.4 above.

4.4.2.5 End-of-Life

Management of end-of-life treatments for food discards is modeled in the same way as Scenario 1 (see Section **Error! Reference source not found.**) with the exception of the assumed fate of food loss that occurs at the receiving facility. Urban Gleaners informed DEQ that food loss that occurs at their facilities is fed directly to swine; however, no data on the environmental impacts/benefits of this disposition pathway were available. As such, food discards here are managed identically to wasted food.

Table 16 – Mix of End-of-life Disposition for Loss and Waste across Life Cycle in Percent (%)

Type	Transport Loss	Facility 1 Loss	Facility 2 Loss	Wasted Food
Anaerobic Digestion	n/a	3.32	n/a	3.32
Aerobic Composting	n/a	9.76	n/a	9.76
Incineration	n/a	4.54	n/a	4.54
Landfill	n/a	82.37	n/a	82.37

4.5 Scenario 4 – Retail Donation Direct to Pantry

4.5.1 Overview of Life Cycle

This scenario represents rescue of packaged food from retail stores. This is a common food rescue pathway for food rescue organizations of varying type and scale. Oregon Food Bank obtains food directly from retailers through its Fresh Alliance program, which is a partnership between the OFB and various grocer retailers.[3] Smaller food rescue organizations, such as food pantries, obtain food through direct donations from retailers as well. This scenario is modeled based on primary data obtained from Clackamas Service Center (CSC), whichoperates a small food pantry that, in addition to food rescue, provides an array of other services to its clients. Under this scenario, packaged food is collected from various retailers within close proximity to the pantry. This is done using small trucks or vans. The rescued food is collected and aggregated at CSC where it is partitioned into meal boxes for individuals and families. The food is not repackaged. The screen capture of the underlying LCI model for this scenario (Figure 6) illustrates the pathway and quantifies the flows across each stage of the lifecycle. Subsequent screenshots will look similar, though the underlying parameters like loss and waste rates will be varied, as will the quantities of flows at each stage. Three sub-scenarios are included:

- S4_07 - Retail Donation to PA (CSC)
- S4_14 - Retail Donation to PA (CSC)
- S4_20 - Retail Donation to PA (CSC)

[3] OFB Fresh Alliance - https://www.oregonfoodbank.org/give/donate-food/food-industry-donations/

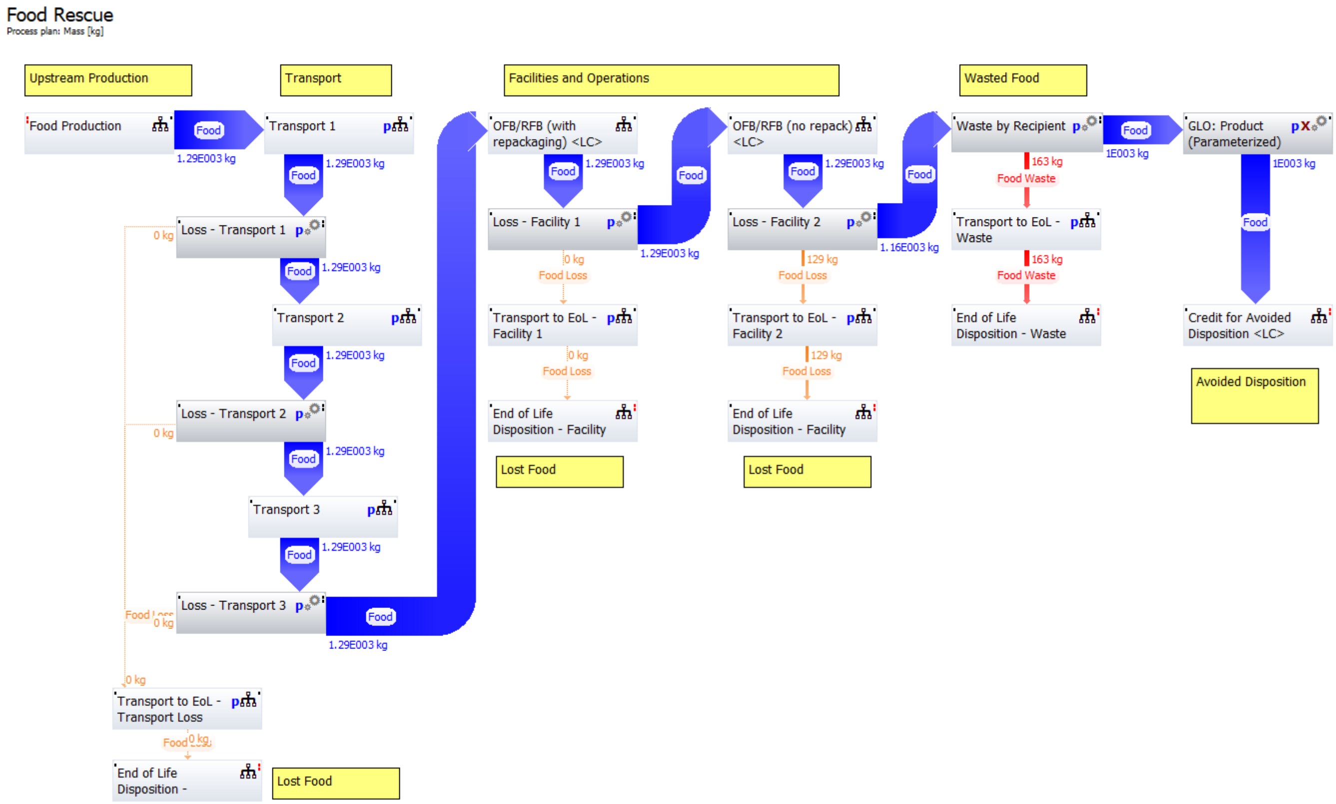


Figure 6 - Model for Food Rescue from Retail to PA with Default Waste/Loss Rates

4.5.2 Description of Process Flow

Each step along the rescue chain for this pathway is described below. Unit process details are shown where primary data was collected and key variables are enumerated.

4.5.2.1 Transport for Food Rescue

Transportation mode and distance is based on data provided by Clackamas Service Center from CY 2015. The distance reflects the true average for all retail rescue and the mode is based on CSC's van mileage logs for their Ford E-250 van. There is no additional transport of the rescued food between food banks or other pantries; CSC handles all transport.

Table 17 – Food Rescue Transport Legs by Mode and Distance – Retail to PA

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
1	From retailer to CSC	4.6	Truck – Medium Heavy-duty Diesel Truck / 9,333 lb payload – 3	thinkstep	2017	US	no

4.5.2.2 Receiving and Processing at Food Banks and/or Partner Agencies

For this scenario, based on information obtained in an interview with CSC, rescued food is taken directly to a food pantry, or "partner agency," as the OFB refers to these organizations No repackaging occurs, as the type of food rescued from retailers (in this case) is already packaged. To model the impacts of receiving and processing primary data provided by Oregon Food Bank were used (see Table 7 for LCI) as a proxy. Losses that occur at the facility are described further in Section 4.5.2.3

4.5.2.3 Losses and Waste

See description of losses and waste in Section 4.2.2.3, for loss and waste rates in this scenario see Table 18 below.

Table 18 – Loss and Waste Rates for Scenario 4

Type	Percent (%)
Loss due to Transport	n/a
Loss at Partner Agency Facilities	10
Wasted Food Scenarios	7, 14, 20

4.5.2.4 Transport of Loss and Waste to End-of-Life Disposition

Transport of food loss and waste to end-of-life disposition is modeled in the same way as Scenario 1 and is described in Sections 4.2.2.4 above.

4.5.2.5 End-of-Life

Management of end-of-life treatments for food discards is modeled in the same way as Scenario 1 (see Section **Error! Reference source not found.**) with the exception of the assumed fate of food loss that occurs at the receiving facility. Whereas, in Scenario 1 food discards are 100 percent composted, here food discards are managed identically to wasted food. Though CSC reported a desire to compost discarded food, they did not have the means to do so and while they actively manage their food discards through pig feeding, no LCI data was available to model this fate.

Table 19 – Mix of End-of-life Disposition for Loss and Waste across Life Cycle in Percent (%)

Type	Transport Loss	Facility 1 Loss	Facility 2 Loss	Wasted Food
Anaerobic Digestion	n/a	3.32	n/a	3.32
Aerobic Composting	n/a	9.76	n/a	9.76
Incineration	n/a	4.54	n/a	4.54
Landfill	n/a	82.37	n/a	82.37

4.6 Scenario 5 – Retail Donation to Food Bank

4.6.1 Overview of Life Cycle

This scenario represents rescue of packaged food from retail stores and is analogous to scenario 4, except that it includes rescue operations (transport and facilities) associated with a large regional food bank, before distribution to a partner agency. Oregon Food Bank obtains food directly from retailers through its Fresh Alliance program, which is a partnership between the OFB and various grocer retailers.[4] Smaller food rescue organizations, such as food pantries obtain food through direct donations from retailers as well, but in this scenario, they receive the food directly from a regional food bank. This scenario is modeled on a mix of primary data obtained from Clackamas Service Center (CSC) and Oregon Food Bank, as well as anecdotal information provided by the Greater Vancouver Food Bank in British Columbia, CA.

Under this scenario, packaged food is collected from various retailers by a regional food bank. This is done using large refrigerated trucks. The rescued food is collected and aggregated at a regional food bank, where it is culled and sorted. The food is not repackaged. The screen capture of the underlying LCI model for this scenario (Figure 8) illustrates the pathway and quantifies the flows across each stage of the lifecycle. Subsequent screenshots will look similar, though the underlying parameters like loss and waste rates will be varied, as will the quantities of flows at each stage. Three sub-scenarios are included:

[4] OFB Fresh Alliance - https://www.oregonfoodbank.org/give/donate-food/food-industry-donations/

- S5_07 - Retail Donation to Food Bank
- S5_14 - Retail Donation to Food Bank
- S5_20 - Retail Donation to Food Bank

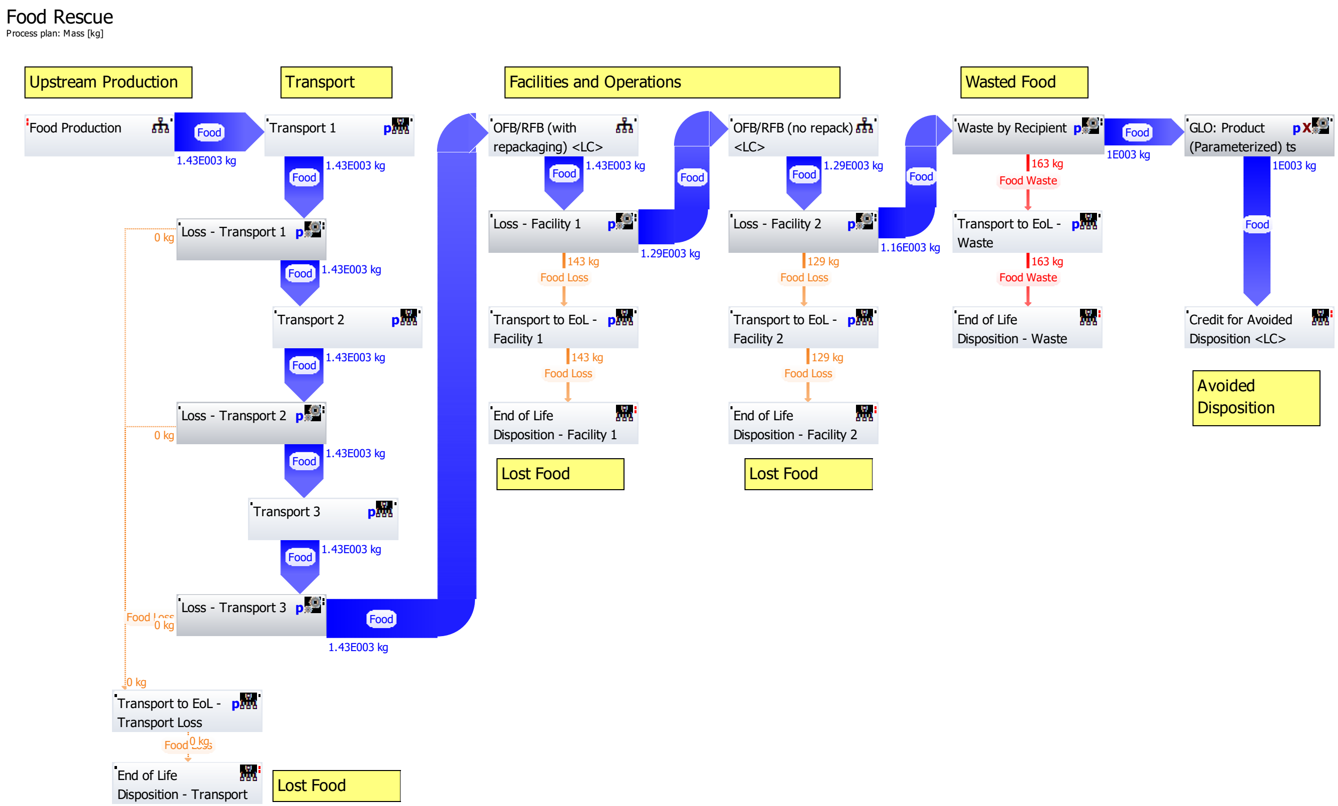


Figure 7 - Model for Food Rescue from Retail to PA with Default Waste/Loss Rates

4.6.2 Description of Process Flow

Each step along the rescue chain for this pathway is described below. Unit process details are shown where primary data was collected and key variables are enumerated.

4.6.2.1 Transport for Food Rescue

Transportation mode and distance is based on estimates provided by Oregon Food Bank and Greater Vancouver Food Bank for the first leg and data from Clackamas Service Center for the second leg.

Table 20 – Food Rescue Transport Legs by Mode and Distance – Retail to Food Bank to Partner Agency

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
1	From retailer to RFB	40	Truck - Insulated Refrigerated / 13,000 lb payload – 7	Thinkstep	2017	US	no

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
2	From RFB to PA	4.6	Truck – Medium Heavy-duty Diesel Truck / 9,333 lb payload – 3	thinkstep	2017	US	no

4.6.2.2 Receiving and Processing at Food Banks and/or Partner Agencies

For this scenario, rescued food is first taken to a regional food bank and then to a food pantry, or "partner agency," as the OFB refers to these organizations. No repackaging occurs, as the type of food rescued from retailers (in this case) is already packaged. To model the impacts of receiving and processing primary data provided by Oregon Food Bank were used (see Table 7 for LCI) as a proxy. Losses that occur at the facility are described further in Section 4.6.2.3.

4.6.2.3 Losses and Waste

See description of losses and waste in Section 4.2.2.3, for loss and waste rates in this scenario see Table 21 below.

Table 21 – Loss and Waste Rates for Scenario 5

Type	Percent (%)
Loss due to Transport	n/a
Loss at Cull/Sort at Facilities	10
Loss at Partner Agency Facilities	10
Wasted Food Scenarios	7, 14, 20

4.6.2.4 Transport of Loss and Waste to End-of-Life Disposition

Transport of food loss and waste to end-of-life disposition is modeled in the same way as Scenario 1 and is described in Section 4.2.2.4 above.

4.6.2.5 End of life

Management of end-of-life treatments for food discards is modeled in the same way as Scenario 1 (see Section 4.2.2.5 above**Error! Reference source not found.**) where food discards that occur at the regional food bank are 100 percent composted. Losses and thus food discards that occur at the pantry (aka partner agency) are estimated to be handled by the same mix of fates of wasted food in the MSW stream for Oregon.

Table 22 – Mix of End-of-life Disposition for Loss and Waste across Life Cycle in Percent (%)

Type	Transport Loss	Facility 1 Loss	Facility 2 Loss	Wasted Food
Anaerobic Digestion	n/a	0	3.32	3.32
Aerobic Composting	n/a	45.19%	9.76	9.76
Incineration	n/a	0	4.54	4.54
Landfill	n/a	54.81%	82.37	82.37

4.7 Scenario 6 – Prepared Food from Retail to Pantry

4.7.1 Overview of Life Cycle

This scenario represents rescue of prepared food from retail stores. Prepared food is defined as "Food sold in a heated state or heated by the seller, or two or more food ingredients mixed or combined by the seller for sale as a single item, but not including food that is only cut, repackaged, or pasteurized by the seller." Not all food rescue organizations rescue prepared food for various reasons, but primarily due to concerns regarding provenance and food safety. Smaller food rescue organizations, such as food pantries, obtain prepared food through direct donations from retailers as well. This scenario is modeled based on primary data obtained from Clackamas Service Center (CSC) and so follows the transport modes and distance from Scenario 4 above.

Under this scenario, prepared food is collected from various retailers within close proximity to the pantry. This is done using small trucks or vans. The rescued food is collected and aggregated at CSC where it is partitioned into meal boxes for individuals and families, or served directly. The food is often (but not always) repackaged. In this scenario, repackaging is included. The screen capture of the underlying LCI model for this scenario (Figure 8) illustrates the pathway and quantifies the flows across each stage of the lifecycle. Subsequent screenshots will look similar, though the underlying parameters like loss and waste rates will be varied, as will the quantities of flows at each stage. Three sub-scenarios are included:

- S6_07 - Prepared Food from Retail (Estimate)
- S6_14 - Prepared Food from Retail (Estimate)
- S6_20 - Prepared Food from Retail (Estimate)

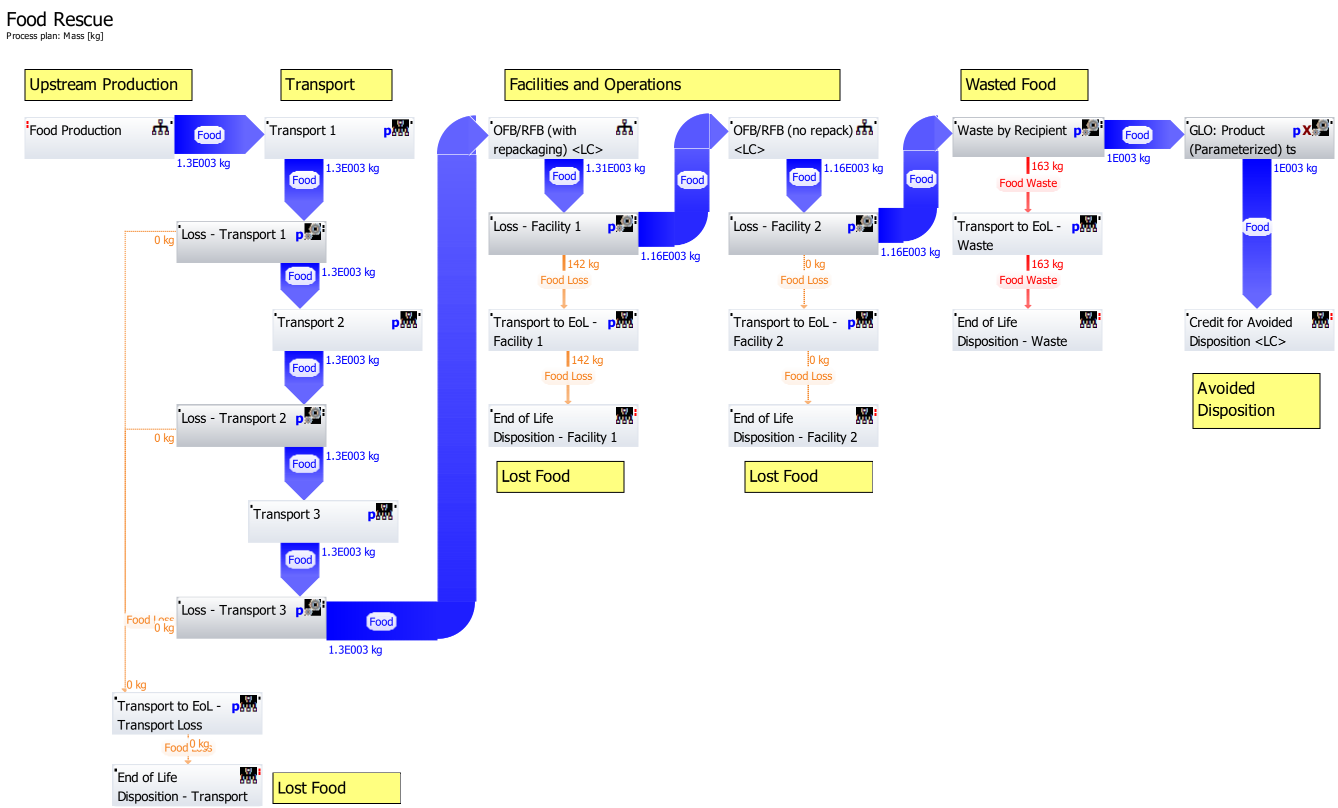


Figure 8 - Model for Prepared Food Rescue from Retail to PA with Default Waste/Loss Rates

4.7.2 Description of Process Flow

Each step along the rescue chain for this pathway is described below. Unit process details are shown where primary data was collected and key variables are enumerated.

4.7.2.1 Transport for Food Rescue

Transportation mode and distance is based on data provided by Clackamas Service Center from CY 2015. The distance reflects the true average for all retail rescue and the mode is based on CSC's van mileage logs for their

Ford E-250 van. There is no additional transport of the rescued food between food banks or other pantries; CSC handles all transport.

Table 23 – Food Rescue Transport Legs by Mode and Distance – Prepared Food from Retail to PA

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
1	From retailer to PA	4.6	Truck – Medium Heavy-duty Diesel Truck / 9,333 lb payload – 3	thinkstep	2017	US	no

4.7.2.2 Receiving and Processing at Food Banks and/or Partner Agencies

For this scenario, based on information obtained in an interview with CSC, rescued food is taken directly to a food pantry, or "partner agency," as the OFB refers to these organizations. Repackaging does occur as often-prepared food is collected in bulk. To model the impacts of receiving and processing, primary data provided by Oregon Food Bank were used (see Table 7 for LCI) as a proxy. Losses that occur at the facility are described further in Section 4.7.2.3.

4.7.2.3 Losses and Waste

See description of losses and waste in Section 4.2.2.3, for loss and waste rates in this scenario see Table 24. The loss rate for prepared foods is slightly higher than for the previous retail donation scenario. This loss rate is based on prepared food donation records provided by New Seasons Market, a regional grocery retail chain in Oregon, Washington and California.

Table 24 – Loss and Waste Rates for Scenario 6

Type	Percent (%)
Loss due to Transport	n/a
Loss at Partner Agency Facilities	10.9
Wasted Food Scenarios	7, 14, 20

4.7.2.4 Transport of Loss and Waste to End-of-Life Disposition

Transport of food loss and waste to end-of-life disposition is modeled in the same way as Scenario 1 and is described in Section 4.2.2.4 above.

4.7.2.5 End-of-Life

Management of end-of-life treatments for food discards is modeled in the same way as Scenario 1 (see Section 4.2.2.5 above) with the exception of the assumed fate of food loss that occurs at the receiving facility. Whereas, in Scenario 1 food discards are 100 percent composted, here food discards are managed identically to wasted food. Though CSC reported a desire to compost discarded food, they did not have the means to do so and while they actively manage their food discards through pig feeding, no LCI data was available to model this fate.

Table 25 – Mix of End-of-life Disposition for Loss and Waste across Life Cycle in Percent (%)

Type	Transport Loss	Facility 1 Loss	Facility 2 Loss	Wasted Food
Anaerobic Digestion	n/a	3.32	n/a	3.32
Aerobic Composting	n/a	9.76	n/a	9.76
Incineration	n/a	4.54	n/a	4.54
Landfill	n/a	82.37	n/a	82.37

4.8 Scenario 7 – Prepared Food Donation Direct

4.8.1 Overview of Life Cycle

This scenario represents a unique and limited scale rescue pathway for prepared food. Through an interview with Providence Health and Services (PHS), a non-profit network of hospitals and health care providers, DEQ learned of this hyper-local direct donation pathway for prepared foods. Prepared food is defined as "Food sold in a heated state or heated by the seller, or two or more food ingredients mixed or combined by the seller for sale as a single item, but not including food that is only cut, repackaged, or pasteurized by the seller." This scenario is modeled based on anecdotal interview data obtained from PHS.

Under this scenario prepared food is collected from the cafeteria of Providence's Milwaukie hospital and transported by foot directly to a low-income housing development. The rescued food is collected, transported and served directly to the tenants of the housing development. The food is not repackaged. The screen capture of the underlying LCI model for this scenario (Figure 9) illustrates the pathway and quantifies the flows across each stage of the lifecycle. Subsequent screenshots will look similar, though the underlying parameters like loss and waste rates will be varied, as will the quantities of flows at each stage. Three sub-scenarios are included:

- S7_07 - Direct Donation of Prepared Food (Estimate)
- S7_14 - Direct Donation of Prepared Food (Estimate)
- S7_20 - Direct Donation of Prepared Food (Estimate)

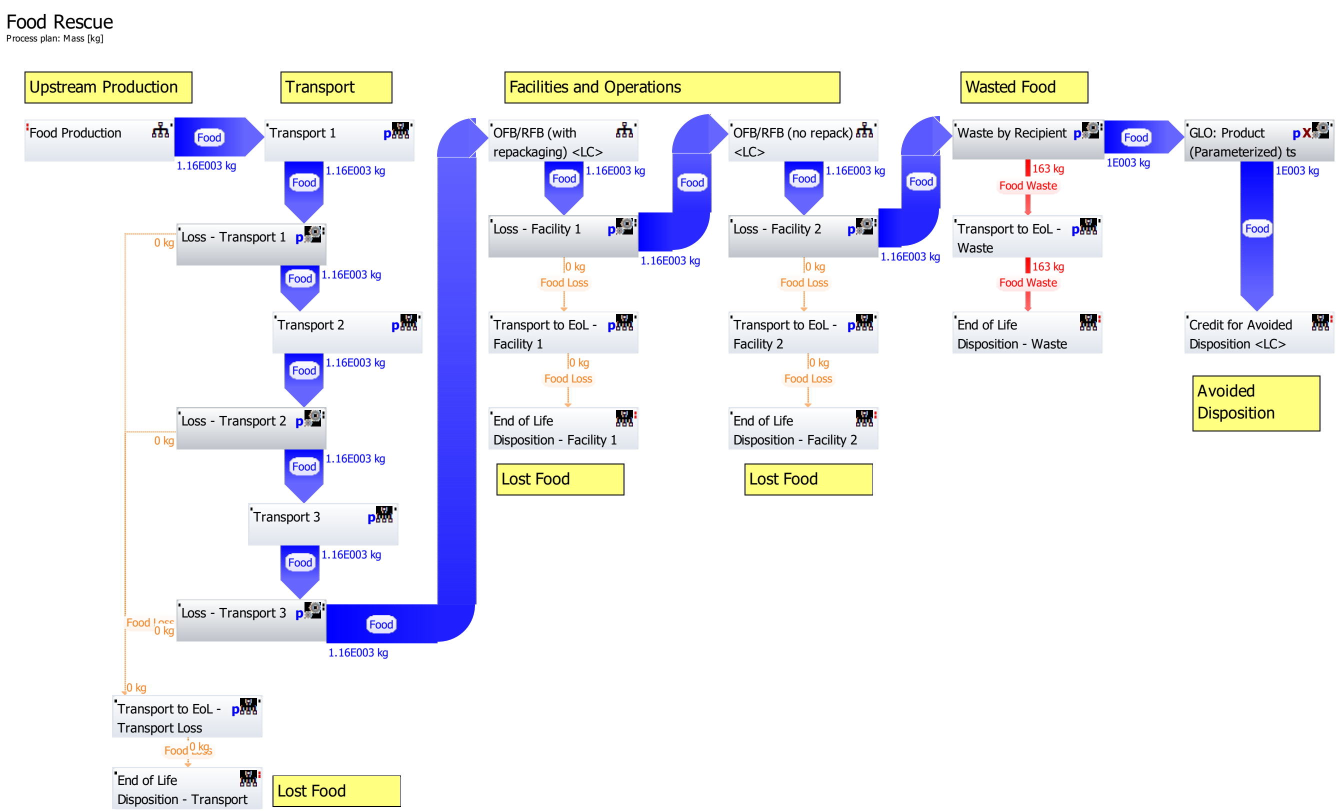


Figure 9 - Model for Prepared Food Rescue from Retail to PA with Default Waste/Loss Rates

4.8.2 Description of Process Flow

Each step along the rescue chain for this pathway is described below. Unit process details are shown where primary data was collected and key variables are enumerated.

4.8.2.1 Transport for Food Rescue

Transportation of rescued food is done by foot.

4.8.2.2 Receiving and Processing at Food Banks and/or Partner Agencies

For this scenario, based on an interview with PHS, rescued food is taken directly to a low-income housing development and provided to tenants directly. No processing or facility related impacts are included for rescue. Losses that occur at the facility are described further in Section 4.7.2.3.

4.8.2.3 Losses and Waste

See description of losses and waste in Section 4.2.2.3, for loss and waste rates in this scenario see Table 26 below. The loss rate for prepared foods is based on prepared food donation records provided by New Seasons Market, a regional grocery retail chain in Oregon, Washington and California. This loss rate is used as a proxy as no primary data from Providence and the housing development was available.

Table 26 – Loss and Waste Rates for Scenario 7

Type	Percent (%)
Loss due to Transport	n/a
Loss at Partner Agency Facilities	n/a
Wasted Food Scenarios	7, 14, 20

4.8.2.4 Transport of Loss and Waste to End-of-Life Disposition

Transport of food loss and waste to end-of-life disposition is modeled in the same way as Scenario 1 and is described in Section 4.2.2.4 above.

4.8.2.5 End of life

Management of end-of-life treatments for food discards is modeled in the same way as Scenario 1 (see Section 4.2.2.5 above). However, in this scenario there is no facility level food loss, as the food is not handled in any facilities, and so there is no end-of-life treatment for discarded foods until it become wasted food.

Table 27 – Mix of End-of-life Disposition for Loss and Waste across Life Cycle in Percent (%)

Type	Transport Loss	Facility 1 Loss	Facility 2 Loss	Wasted Food
Anaerobic Digestion	n/a	n/a	n/a	3.32
Aerobic Composting	n/a	n/a	n/a	9.76
Incineration	n/a	n/a	n/a	4.54
Landfill	n/a	n/a	n/a	82.37

4.9 Scenario 8 – Small Business Food Rescue App

4.9.1 Overview of Life Cycle

This scenario represents rescue from small businesses by individual volunteers as part of a crowd-sourced logistics network that leverages a mobile smart phone application – such as, for example, Food Rescue US or

Food Rescue Hero[5]. The parameters and assumptions for this scenario represent an estimate of the impacts associated with this rescue pathway and do not necessarily reflect actual processes.

Under this scenario, food that would be disposed of at the end of the day is obtained from local businesses. As such, the receiving pantry or regional food bank is likely to dispose of a large share of the rescued food without giving it to people, resulting in a high loss rate in the modeled scenarios, described further below. This high rate of disposal is based on the assumption that the food is of limited nutritional value—such as pastries from a coffee shop, near the end of its shelf life—such as a tray of prepared food, or potentially unsafe for consumption—due to unknown food handling practices.

The rescued food is collected and transported by an individual volunteer using their personal vehicle to a receiving partner agency or food bank. The food is not repackaged. The screen capture of the underlying LCI model for this scenario (Figure 10) illustrates the pathway and quantifies the flows across each stage of the lifecycle. Subsequent screenshots will look similar, though the underlying parameters like loss and waste rates will be varied, as will the quantities of flows at each stage. Three sub-scenarios are included:

- S8_07_Car - Local Small Business Food Rescue App (Estimate)
- S8_14_Car - Local Small Business Food Rescue App (Estimate)
- S8_20_Car - Local Small Business Food Rescue App (Estimate)

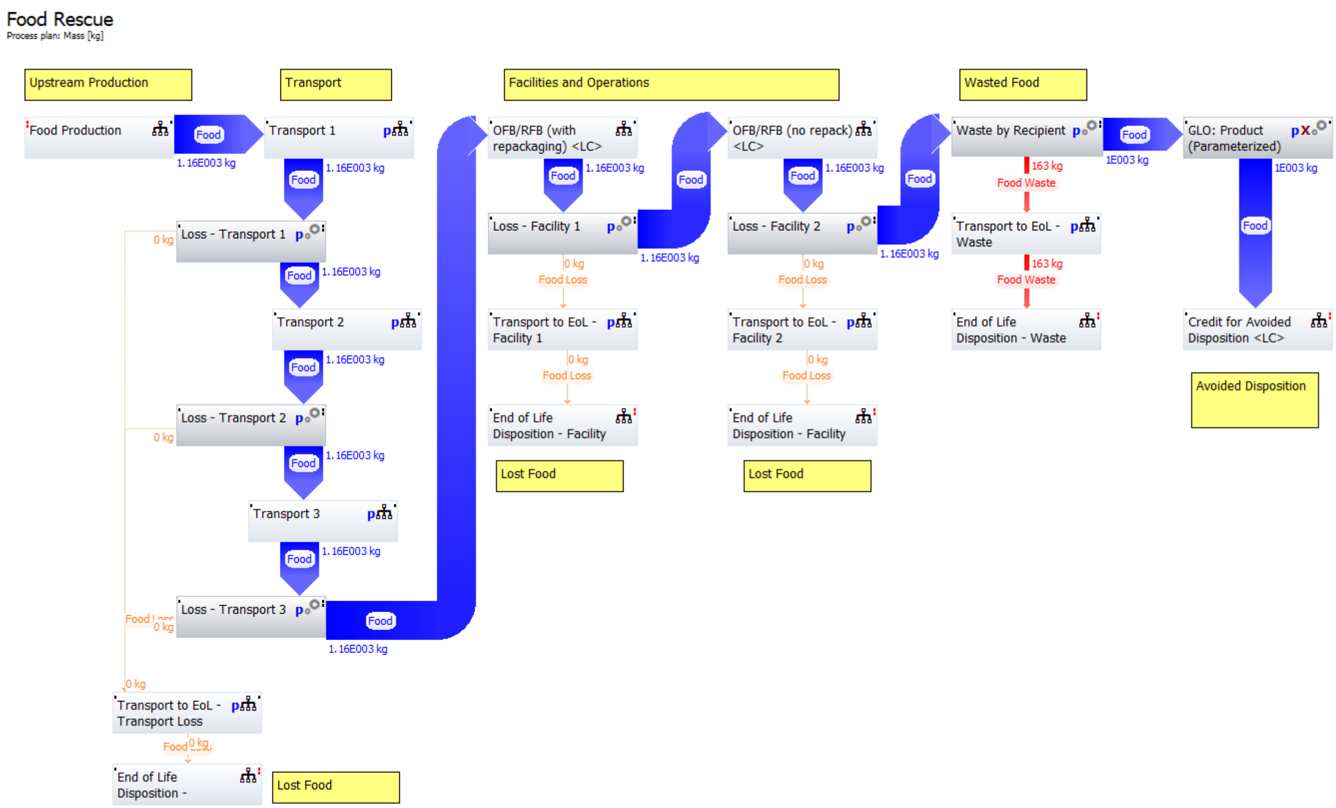


Figure 10 - Model for Local Small Business Food Rescue App with Default Waste/Loss Rates

4.9.2 Description of Process Flow

Each step along the rescue chain for this pathway is described below. Unit process details are shown where primary data was collected and key variables are enumerated.

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[5] Example of food rescue applications - https://foodrescue.us/, https://412foodrescue.org/programs/foodrescuehero/

4.9.2.1 Transport for Food Rescue

Transportation mode and distance are estimated based on the assumption that an individual volunteer operates a passenger vehicle, in this case a car with an efficiency of 24.8 mpg. The distance referenced below is based on primary data provided for the gleaning scenarios above (see Section 4.3). There is no additional transport of the rescued food between food banks or other pantries.

Table 28 – Food Rescue Transport Legs by Mode and Distance – Local Small Business Food Rescue App

Transport Leg	General Name	Distance (mi)	Dataset Name	Source	Reference Year	Geography	Custom
1	From small business to PA/RFB	19.78	Grocery transport by car	thinkstep	2017	US	no

4.9.2.2 Receiving and Processing at Food Banks and/or Partner Agencies

For this scenario, rescued food is assumed to be taken directly to a food pantry, or "partner agency," as the OFB refers to these organizations. Repackaging does not occur. To model the impacts of receiving and processing primary data provided by Oregon Food Bank were used (see Table 7 for LCI) as a proxy. Losses that occur at the facility are described further in Section 4.9.2.3.

4.9.2.3 Losses and Waste

See description of losses and waste in Section 4.2.2.3, for loss and waste rates in this scenario see Table 29 below. The loss rate is an estimate based on the assumption that food rescued from local businesses through this pathway tends to be of low nutritional value, nearing the end of its shelf life or potentially unfit for consumption due to unknown food handling practices. As a result, it is again assumed that partner agencies dispose of the food at a higher rate than healthier, shelf-stable items.

Table 29 – Loss and Waste Rates for Scenario 8

Type	Percent (%)
Loss due to Transport	n/a
Loss at Partner Agency Facilities	50
Wasted Food Scenarios	7, 14, 20

4.9.2.4 Transport of Loss and Waste to End-of-Life Disposition

Transport of food loss and waste to end-of-life disposition is modeled in the same way as Scenario 1 and is described in Section 4.2.2.4 above.

4.9.2.5 End-of-Life

Management of end-of-life treatments for food discards is modeled in the same way as Scenario 1 (see Section 4.2.2.5).

Table 30 – Mix of End-of-life Disposition for Loss and Waste across Life Cycle in Percent (%)

Type	Transport Loss	Facility 1 Loss	Facility 2 Loss	Wasted Food
Anaerobic Digestion	n/a	3.32	n/a	3.32
Aerobic Composting	n/a	9.76	n/a	9.76
Incineration	n/a	4.54	n/a	4.54
Landfill	n/a	82.37	n/a	82.37

4.10 Background Data

4.10.1 Fuels and Energy

National and regional averages for fuel inputs and electricity grid mixes were obtained from the GaBi databases (DB version 8.7, SP36) and Ecoinvent (v3.3). Table 31 lists the relevant LCI datasets used for fuels and energy background data in the food rescue model.

Table 31 - Relevant energy datasets used in inventory analysis

General Name	Dataset Name	Source	Reference Year	Geography	Custom
Electricity	Electricity grid mix – NWPP	thinkstep	2014	US	no
Heat	Thermal energy from natural gas	thinkstep	2014	US	no
Steam	Process steam from natural gas 90%	thinkstep	2014	US	no
Diesel	Diesel mix at refinery	thinkstep	2014	US	no
Gasoline	Gasoline mix (regular) at refinery	thinkstep	2014	US	no
Fuel Oil	Heavy fuel oil at refinery (0.3wt.% S)	thinkstep	2014	US	no
Natural Gas (credit)	Natural gas mix	thinkstep	2014	US	no

4.10.2 Raw Materials and Processes

Background data for all raw materials and unit processes were obtained from the GaBi. Table 32 shows the most relevant LCI datasets used in modeling the food rescue pathways. Full documentation for each dataset can be found at http://www.gabi-software.com/support/gabi/gabi-database-2018-lci-documentation/.

Table 32 - Raw material datasets used in inventory analysis

General Name	Dataset Name	Source	Reference Year	Geography	Custom
Cardboard	Corrugated product	thinkstep/ AF&PA	2012	US	no
Supersacks, Mesh Bags, Clamshells	Polypropylene granulate (PP)	thinkstep	2017	US	no
Poly Bags	Polyethylene film (LDPE/PE-LD)	thinkstep	2017	US	no
Bleach	Sodium hypochlorite solution	thinkstep	2017	US	no
Water	Tap water	thinkstep	2017	EU-28	no
Landfill for Packaging	Plastic waste on landfill, post-consumer	thinkstep	2017	US	no
Waste Water Treatment	Municipal Waste water treatment (US average, cut off approach)	thinkstep	2017	US	no
Landfill for Food	Biodegradable waste on landfill, post-consumer	thinkstep	2017	US	no

General Name	Dataset Name	Source	Reference Year	Geography	Custom
Aerobic Composting	Open windrow composting (incl. compost application and crediting)	BOKU /thinkstep	2017	AT	yes*
Anaerobic Digestion	treatment of biowaste by anaerobic digestion	Ecoinvent	2009	CH	yes*
Incineration	Biodegradable waste in waste incineration plant	thinkstep	2017	US	no

*CO2 balance of inventory adjusted using data from (Morris, Brown, Matthews, & Cotton, 2014) regarding changes in soil carbon storage, which were found to be absent from the default dataset. For AC, -0.12 kg CO2 / kg of food waste and AD, -0.08 kg CO2 / kg of food waste.

4.10.3 Transportation and Distribution

Transportation distances and modes of transport are excluded for the transport of the raw materials (such as new packaging or cleaners) to food rescue facilities. This exclusion can be justified, as these materials comprise a small fraction (less than 1 percent) of the mass associated with fulfilling the functional unit. Of course, transportation is a key element of the foreground system and so details on the transportation distances and modes associated with a given food rescue pathway can be found above in the subsections of Section 4 Life Cycle Inventory Analysis.

The GaBi database for transportation vehicles and fuels was used to model transportation. Truck transportation within the United States was modeled using the GaBi US truck transportation datasets. The vehicle types, fuel usage, and emissions for these transportation processes were developed based on the most recent US Census Bureau Vehicle Inventory and Use Survey (2002) and US EPA emissions standards for heavy trucks in 2007. No other modes (rail, ship or air) of transport were modeled within the system boundary. To account for the round trip transit distances, utilization rates were adjusted (cut in half from default values) so that each leg of transport represents both the empty outbound trip to the site where food was rescued (e.g., picked up) and the return trip to bring the food back to the receiving food bank or partner agency.

4.10.4 Direct Emissions to Air, Water and Soil

No direct emissions were reported by stakeholders and therefore none are taken into account. Oregon Food Bank provided primary data on facility operations based on their Portland, OR headquarters. This facility is not regulated by DEQ for air emissions and their energy comes the form of electricity from the grid, thus no onsite combustion emissions are expected. Similarly, any emissions to water are handled through the municipal wastewater treatment system and solid wastes are handled through composting or the municipal solid waste system.

Data for all upstream materials, electricity and energy carriers were obtained from the GaBi databases (DB version 8.7, SP36) and Ecoinvent (v3.3). The emissions (CO_2, etc.) due to the use of electricity are accounted for with the use of the database processes.

Emissions associated with transportation were determined by capturing the logistical operations of involved organizations (data collected from the organizations for the reference year). Energy use and the associated emissions were calculated using pre-configured transportation models describe above.

4.11 Life Cycle Inventory Analysis Result

ISO 14044 defines the Life Cycle Inventory (LCI) analysis result as the "outcome of a life cycle inventory analysis that catalogues the flows crossing the system boundary and provides the starting point for life cycle impact assessment." Because of the multitudinous number of scenarios evaluated in this study, the inclusion of LCI analysis results in the text of this report is impractical. However, full LCI analysis results are available as a separate supporting information item (S1. FoodRescueLCI_AllScenarios_Grouping.xlsx). The complete inventory comprises hundreds of flows that could be used to recreate the impact assessment.

5. Life Cycle Impact Assessment

This chapter contains the results for the inventory metrics and impact categories defined in section 3.6 broken down by each food rescue scenario. All reported impact categories represent impact potentials, meaning that they are approximations of environmental impacts that could occur if the emissions would follow the underlying fate and transport pathway and meet certain conditions in the receiving environment. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen functional unit, which is a key element of LCA's relative approach.

Therefore, LCIA results are relative expressions only and do not predict actual impacts and without being placed in context nor do they indicate the exceedance of thresholds, safety margins, hazard or risks.

All the results below are expressed relative to the functional unit of 1000 kg of food rescued and consumed.

5.1 Detailed Impact Assessment Results

5.1.1 Food Rescue Results – System Boundary Begins at the Point of Rescue

The system boundary for this study begins at the point of rescue. These results do not include any of the upstream impacts of food production or distribution, which were sunk costs. However, Appendix A – Sensitivity Analysis, contains results in which an expanded system boundary that includes the impacts of upstream food production and distribution are included.

5.1.1.1 Global Warming Potential (GWP)

The LCIA results for GWP show the relevance of transportation to a given scenario. More specifically the mode of transport is the critical determinant of GWP emissions, with scenarios 3 and 8 resulting in the highest emissions. All other scenarios are fairly comparable in terms of net GWP, with scenarios 2, 4, 5, 6, and 7 leading to net negative GWP due to the emissions of all rescue activities (transportation, facilities, disposal of loss or wasted food) being less than the benefit of avoided disposal of the rescued and eaten food (defined by the functional unit as 1000 kg).

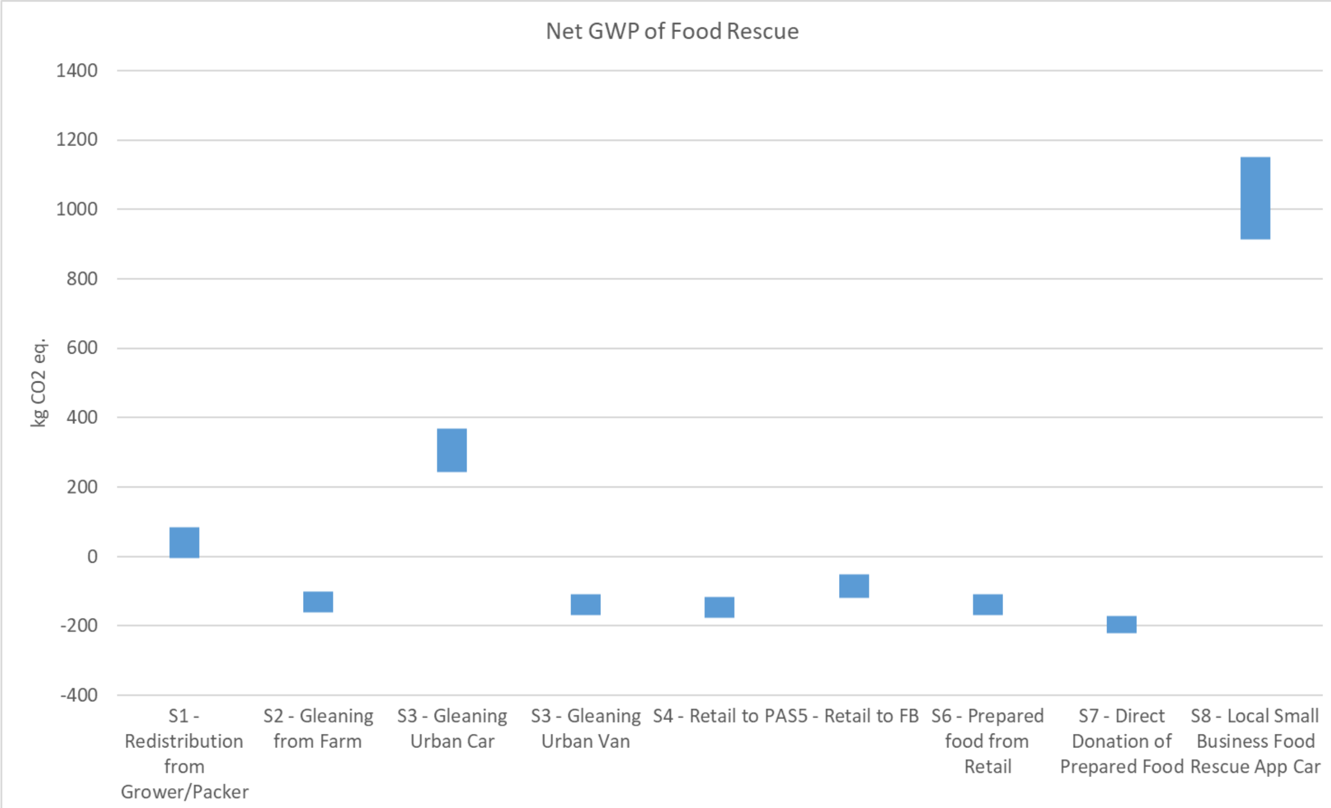

Figure 11 - Range of Net GWP (waste rates of 7-20 percent)

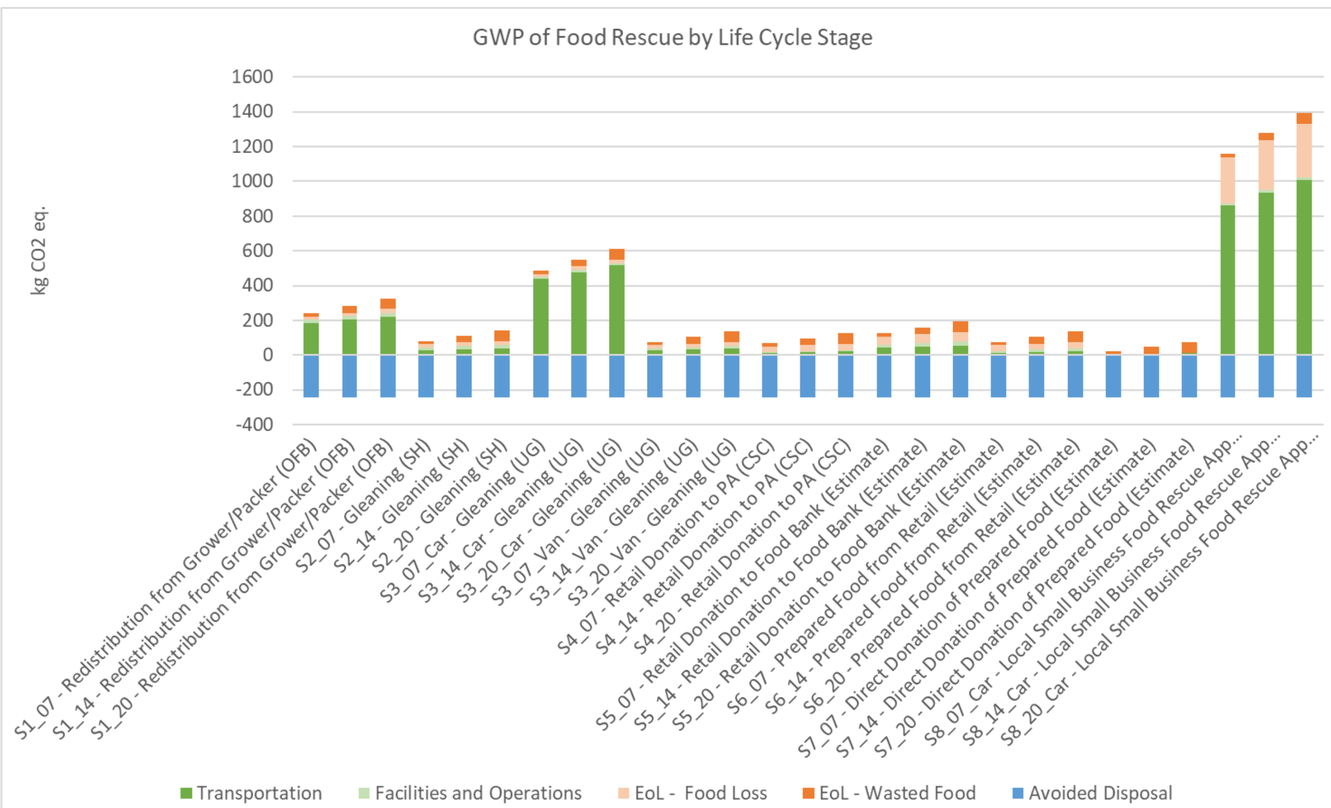

Figure 12 - GWP by Life Cycle Stage for All Scenarios

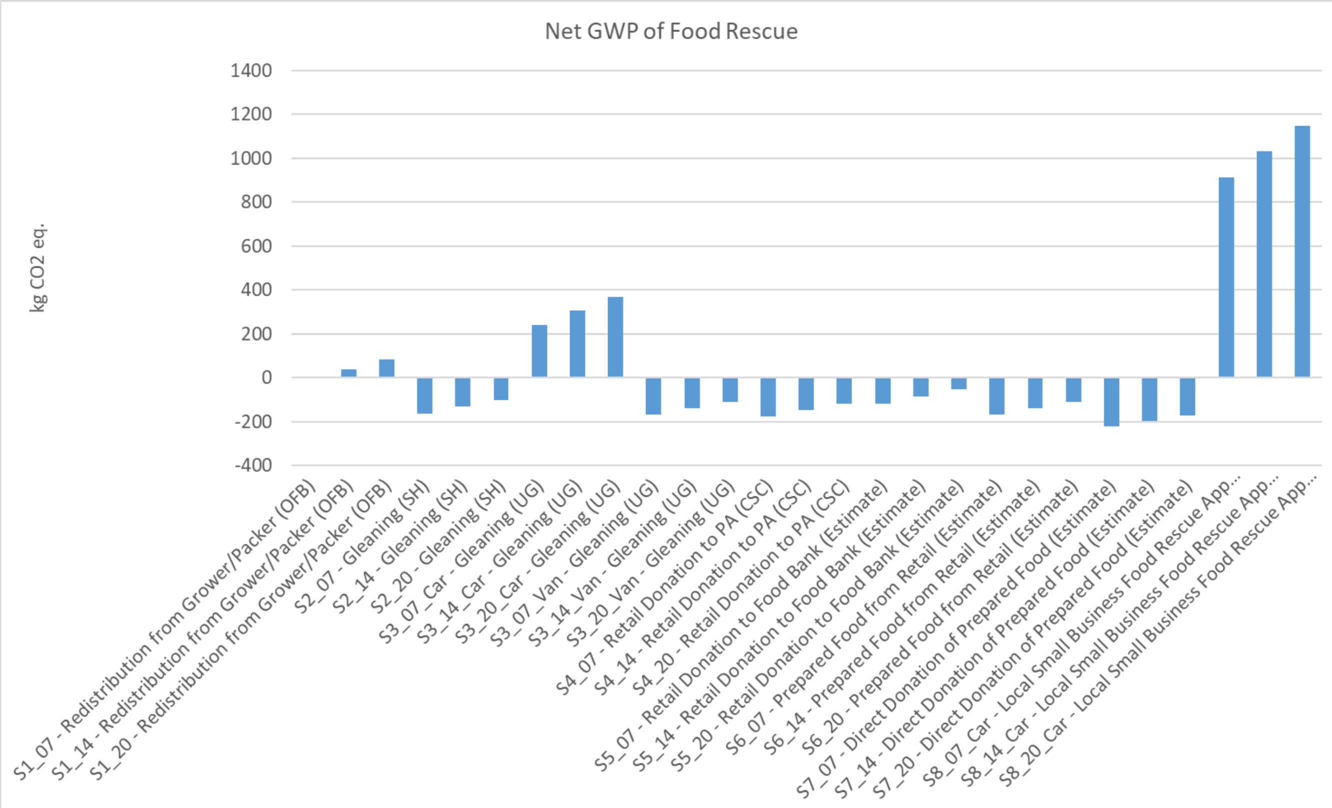

Figure 13 - Net GWP for All Scenarios

5.1.1.2 Eutrophication Potential (EP)

The release of eutrophic compounds is nearly exclusively a function of the disposal pathways, either disposal of lost or wasted food or avoided disposal associated with food rescue. Scenario 8 leads to the highest EP because of the high loss rate for rescued food assumed in that scenario, otherwise all other scenarios are negative (e.g., a credit) with the avoided burden of disposal being the largest contributor to net EP results.

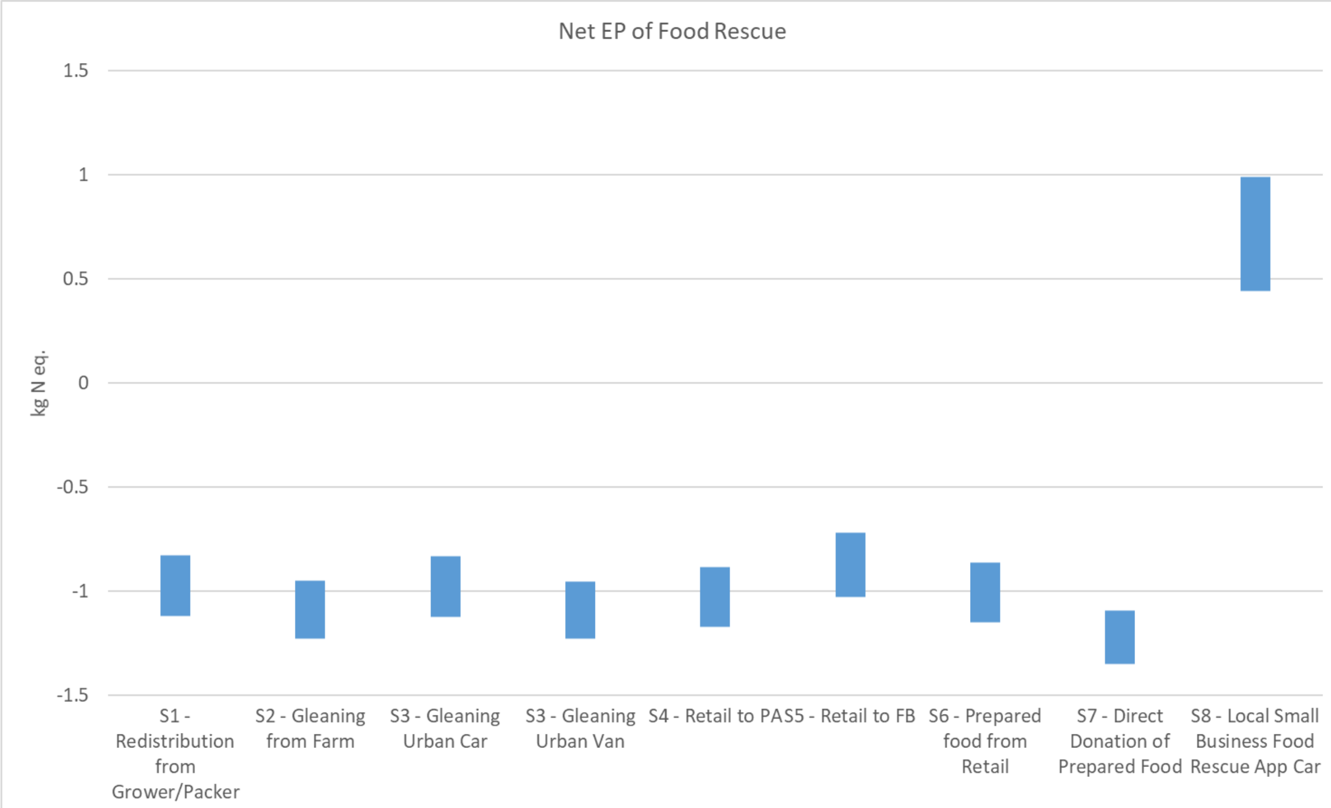

Figure 14 – Range of Net EP (waste rates of 7-20 percent)

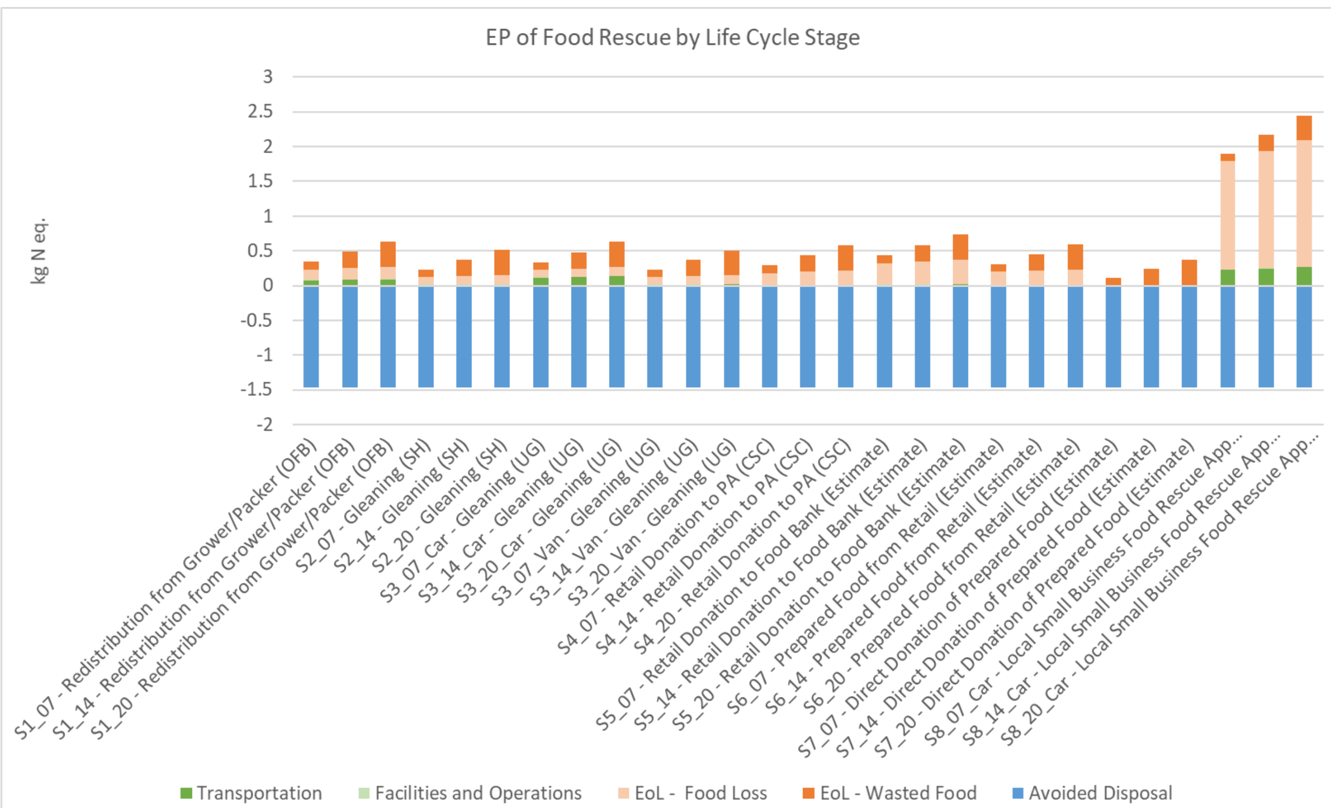

Figure 15 - EP by Life Cycle Stage for All Scenarios

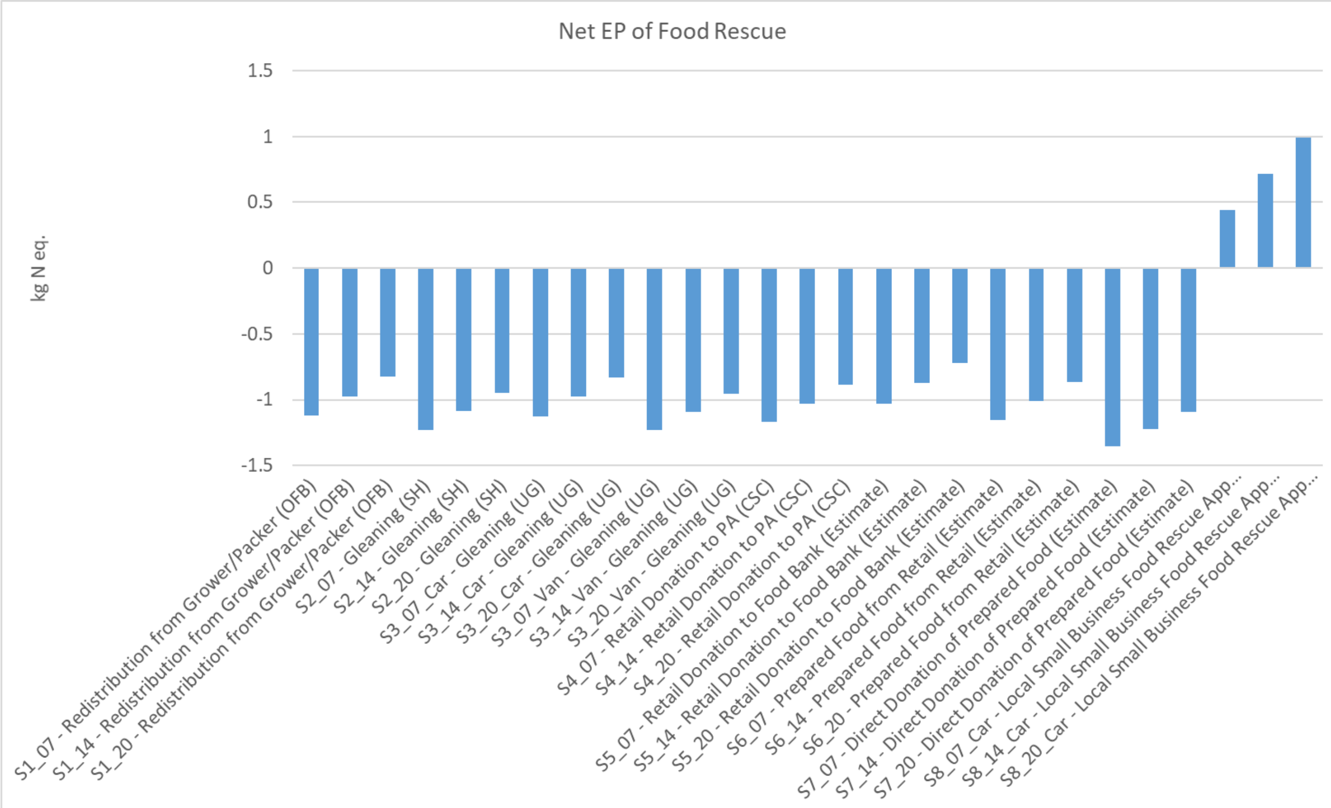

Figure 16 - Net EP for All Scenarios

5.1.1.3 Acidification Potential (AP)

The release of acidifying compounds is nearly exclusively a function of end-of-life disposal pathways, either disposal of lost or wasted food or avoided disposal associated with food rescue. Scenario 8 leads to the highest AP because of the high loss rate for rescued food assumed in that scenario, otherwise all other scenarios are negative (e.g., a credit). In Scenario 8, the next largest contributor to net AP results after disposal is the credit associated with the avoided burden of disposal associated with food rescue. For all other scenarios, the credit of avoided disposal is the largest contributor to the results.

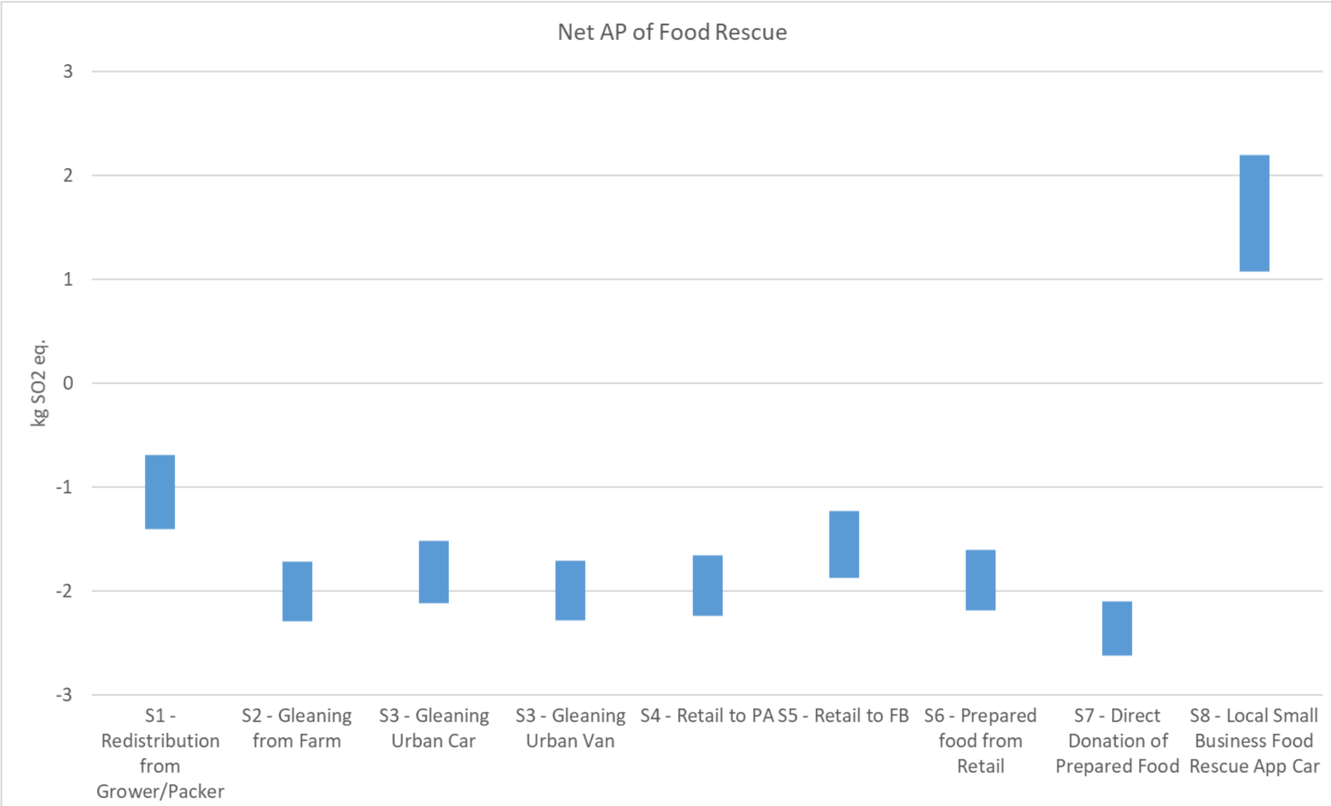

Figure 17 - Range of Net AP (waste rates of 7-20 percent)

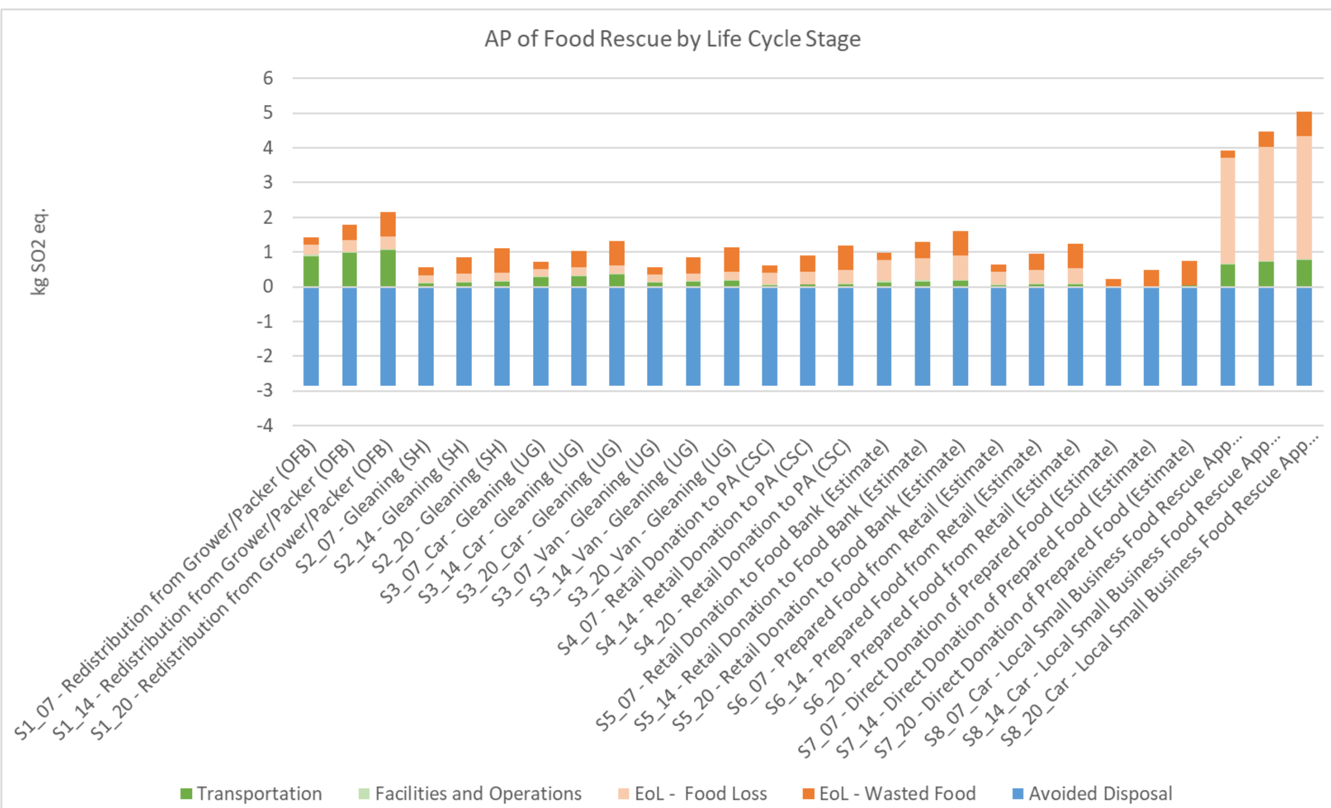

Figure 18 - AP by Life Cycle Stage for All Scenarios

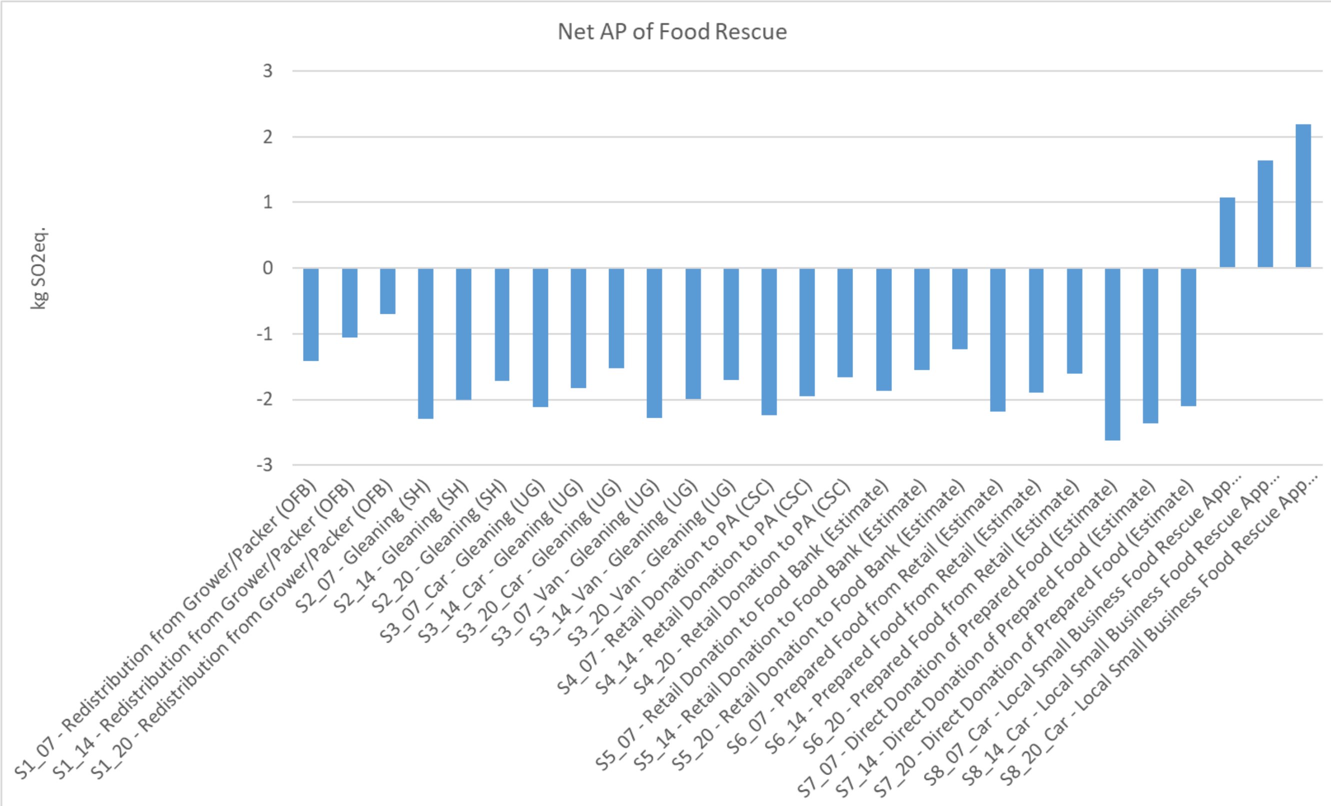

Figure 19 - Net AP for All Scenarios

5.1.1.4 Smog Formation Potential (SFP)

The release of smog forming compounds is associated predominantly with transport distance and mode. As evidenced by the highest releases of ozone equivalents associated with Scenario 1, wherein a class 8 truck hauls rescued food generating the precursors to smog through direct emissions of nitrous oxides. Scenario 8 also has comparatively high smog formation potential, which is a result of the high loss rate assumed, meaning that more car transport must take place and more end-of-life disposition of lost food, to fulfill the functional unit of 1000 kg of rescued food consumed.

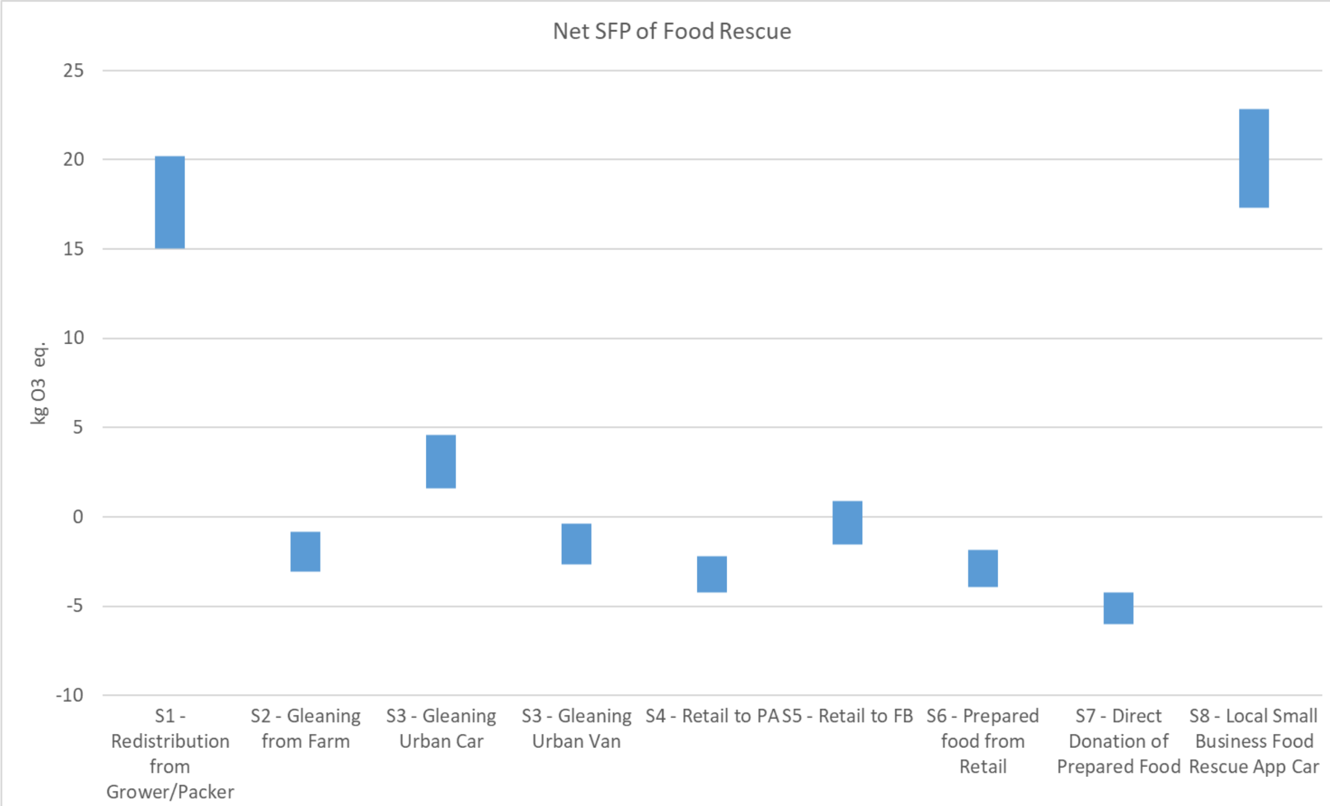

Figure 20 - Range of Net SFP (waste rates of 7-20 percent)

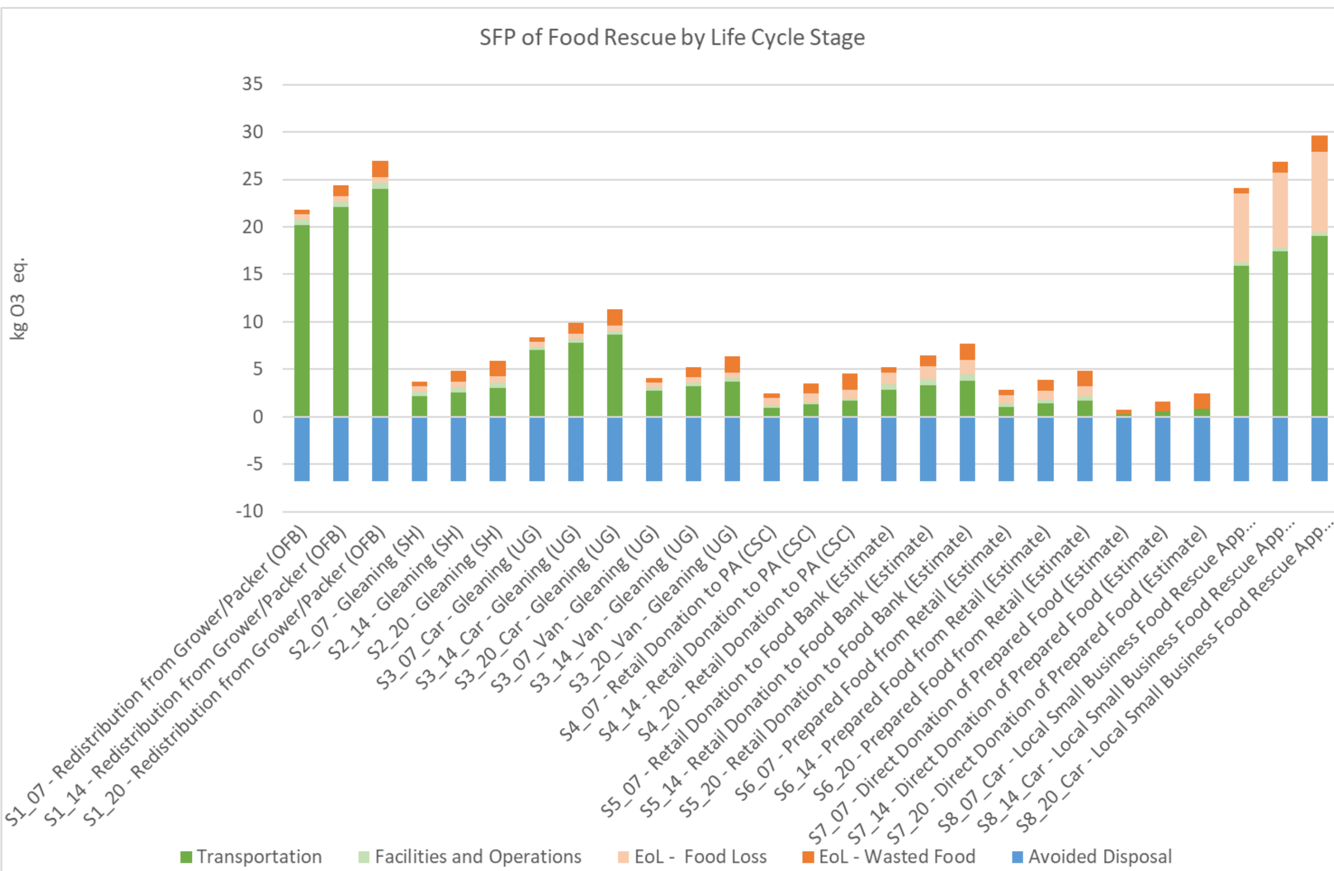

Figure 21 - SFP by Life Cycle Stage for All Scenarios

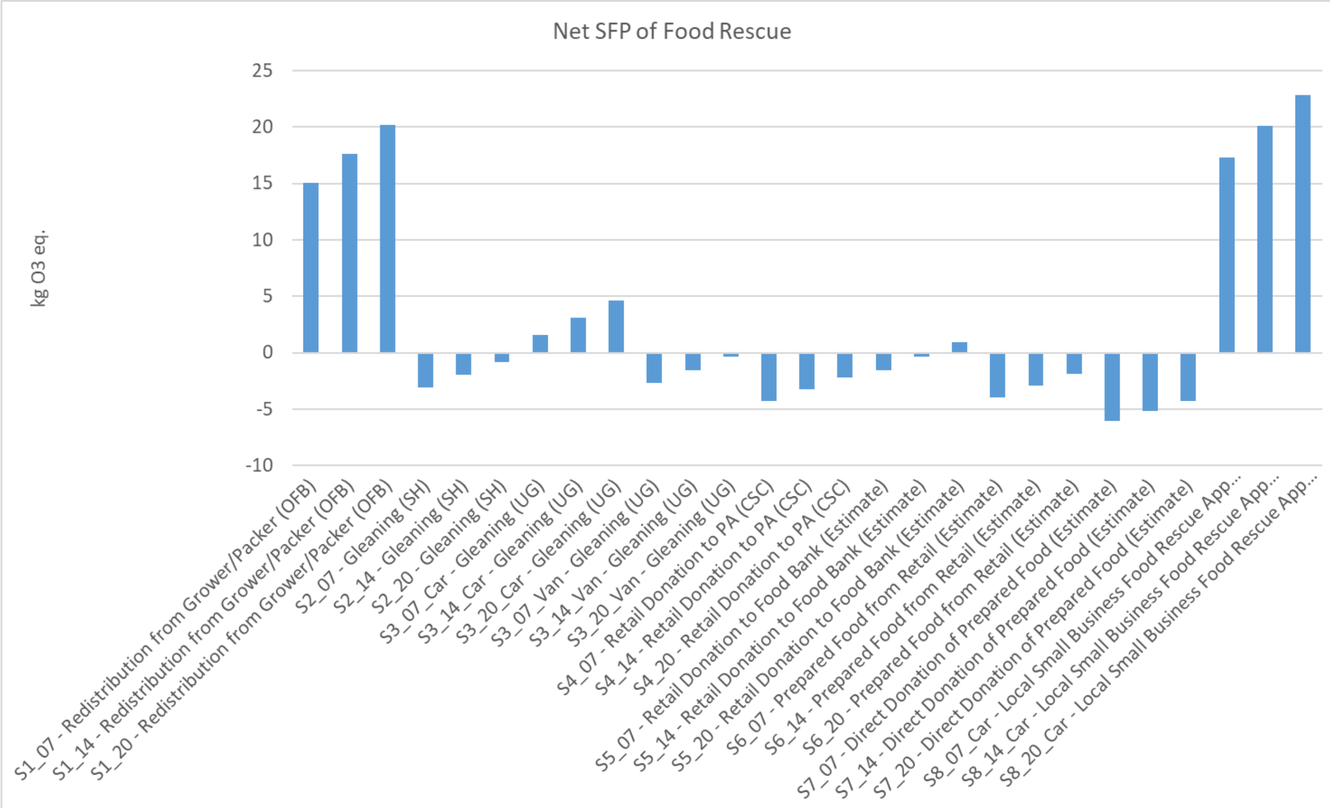

Figure 22 - Net SFP for All Scenarios

5.1.1.5 Ozone Depletion Potential (ODP)

Ozone depletion is one of the only impact categories where transportation is not a relevant contributor to emissions. The release of ozone depleting substances are estimated to be quite small (10E-08) in absolute terms across all scenarios. The sources of ozone forming emissions are predominantly from the production or energy and certain fuels. Since energy and some fuels are required to produce ancillary materials (such as packaging materials, chemicals for cleaning, materials used in composting, inputs to landfills, etc…), these upstream materials and direct uses of energy are what lead to the release of ozone depleting emissions. These ozone-depleting substances also appear in trace amounts in the end-of-life disposition processes, such as within the production of electricity.

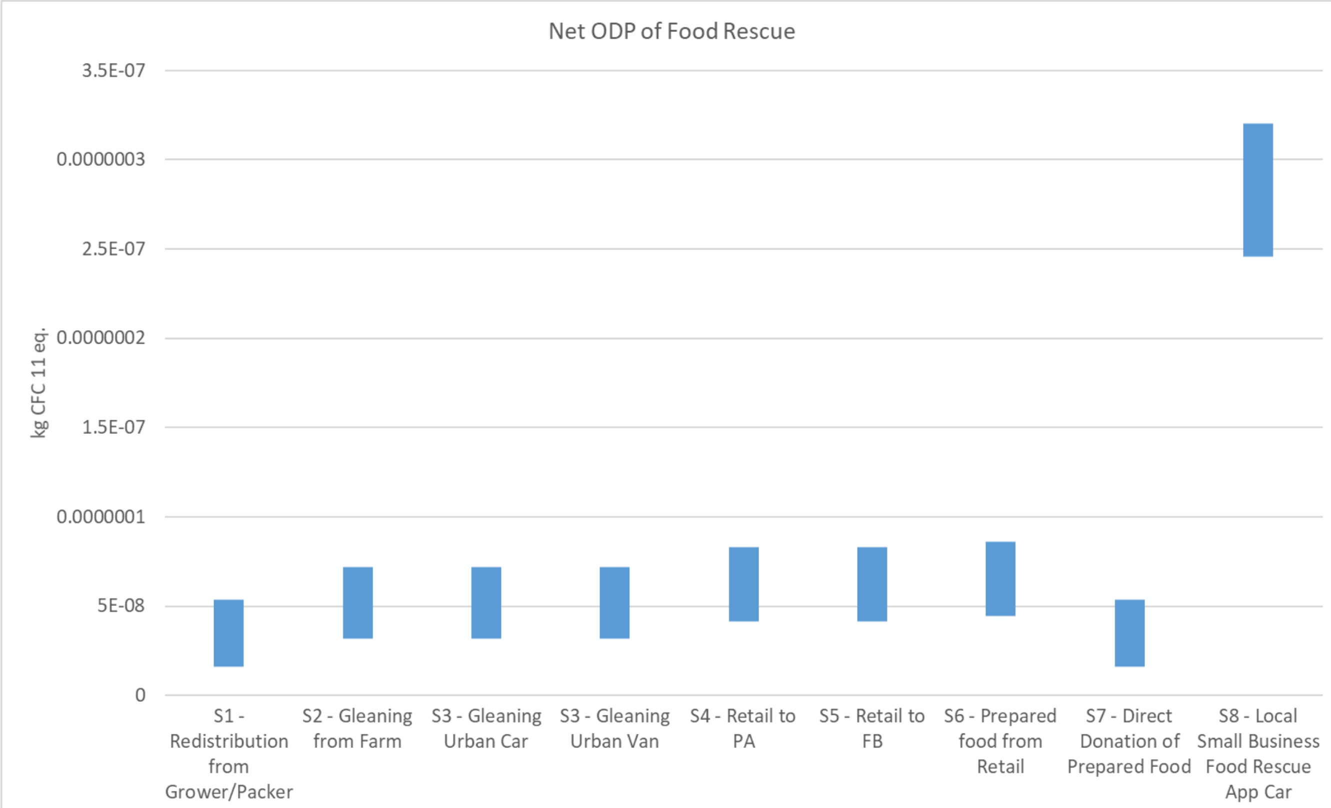

Figure 23 - Range of Net ODP (waste rates of 7-20 percent)

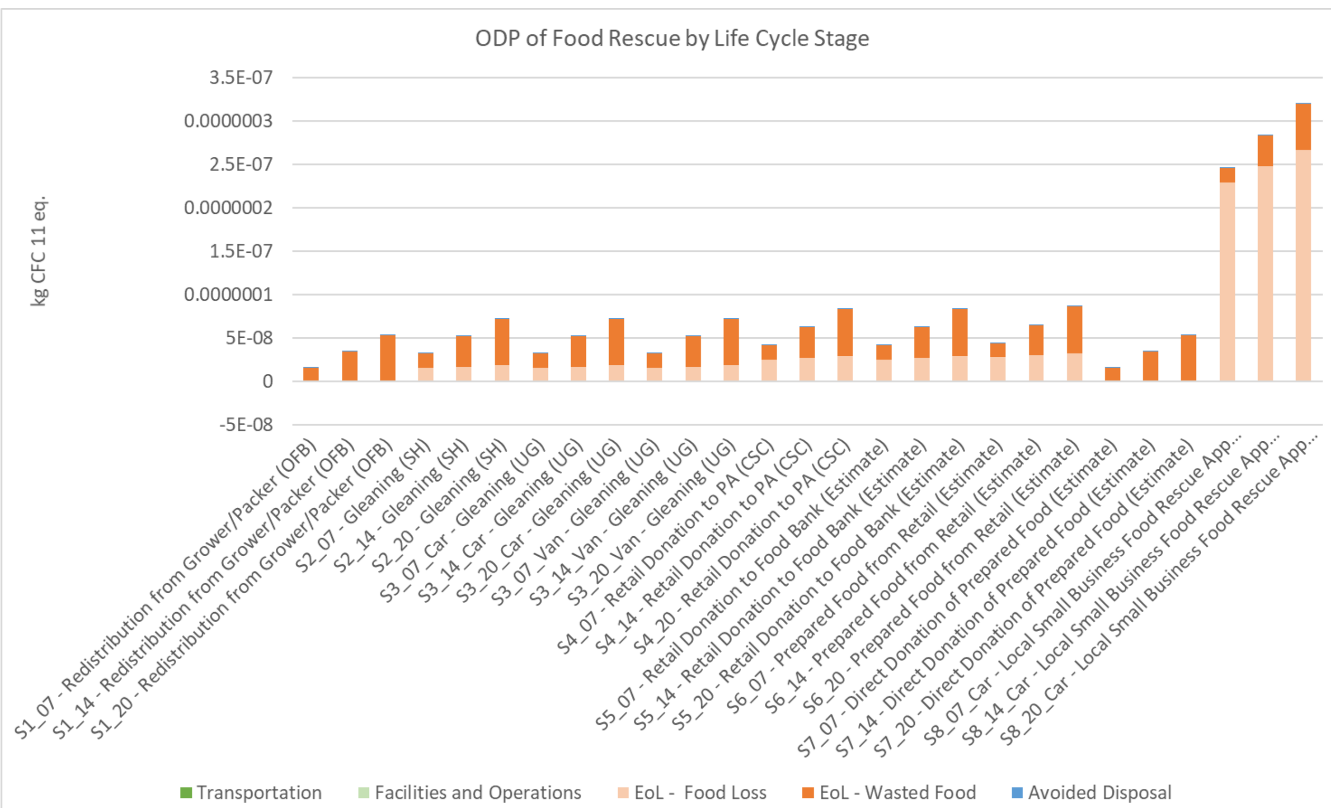

Figure 24 - ODP by Life Cycle Stage for All Scenarios

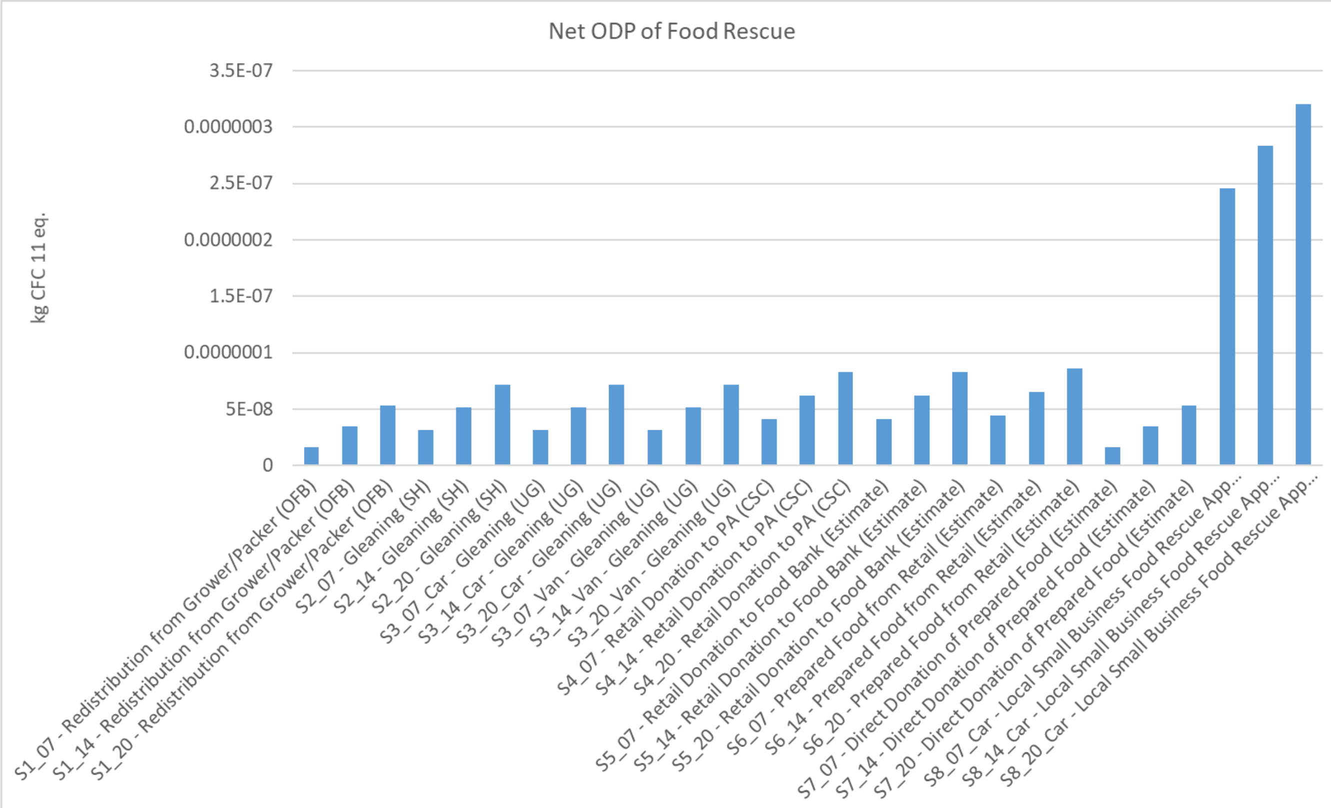

Figure 25 - Net ODP for All Scenarios

5.1.1.6 Human Health Particulate Air (PM2.5)

Transportation, specifically the mode, is the leading cause of particulate matter emissions. As a result, the scenarios for gleaning (S3) by car and local small business food rescue (S8) have the highest potential PM2.5 emissions. Interestingly, avoided disposal can have significant benefits in terms of preventing particulate matter emissions, so in food rescue scenarios where transport is negligible, net results can be negative such as is the case in scenarios 4, 5, 6, and 7. This relevance of disposal towards PM2.5 emissions also has implications in the opposite direction when a high degree of food loss or waste results in particulate matter emissions associated with disposition of that uneaten food.

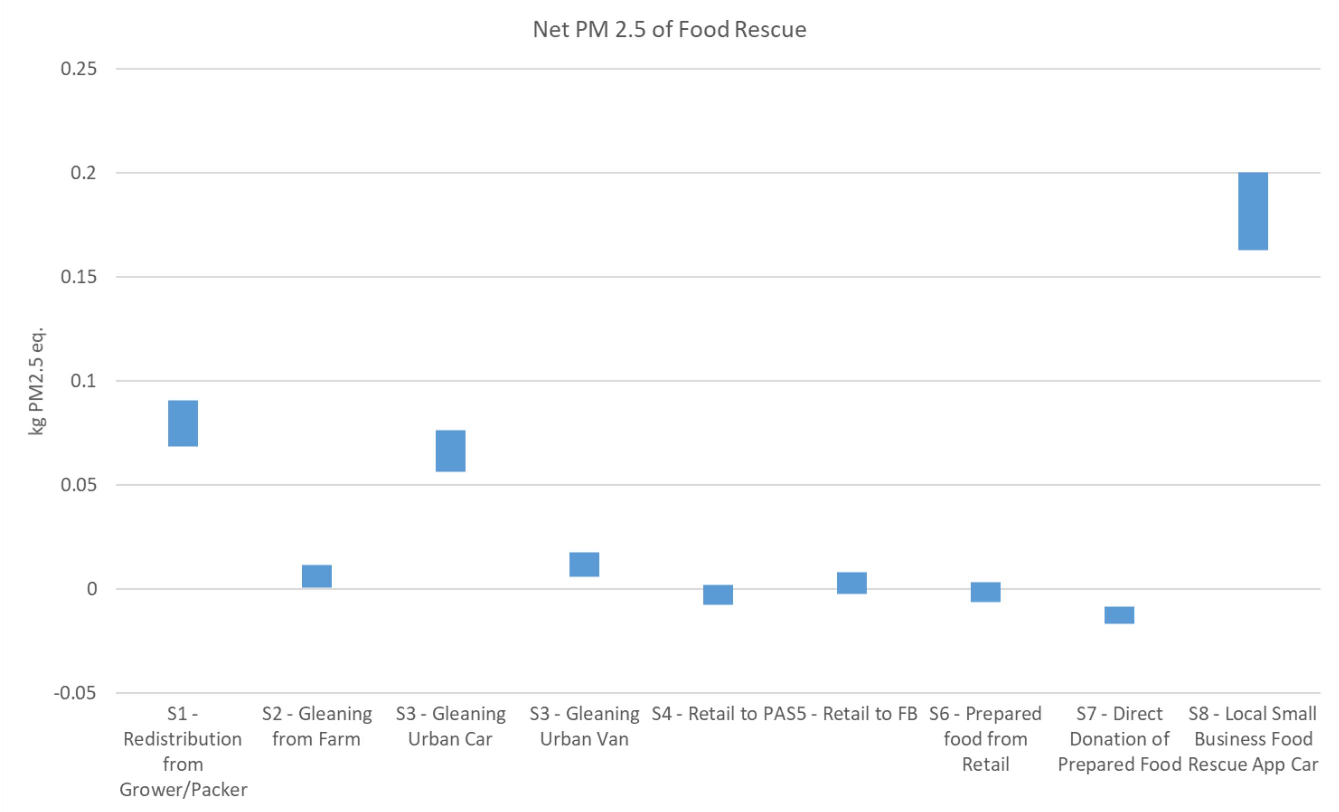

Figure 26 - Range of Net PM2.5 (waste rates of 7-20 percent)

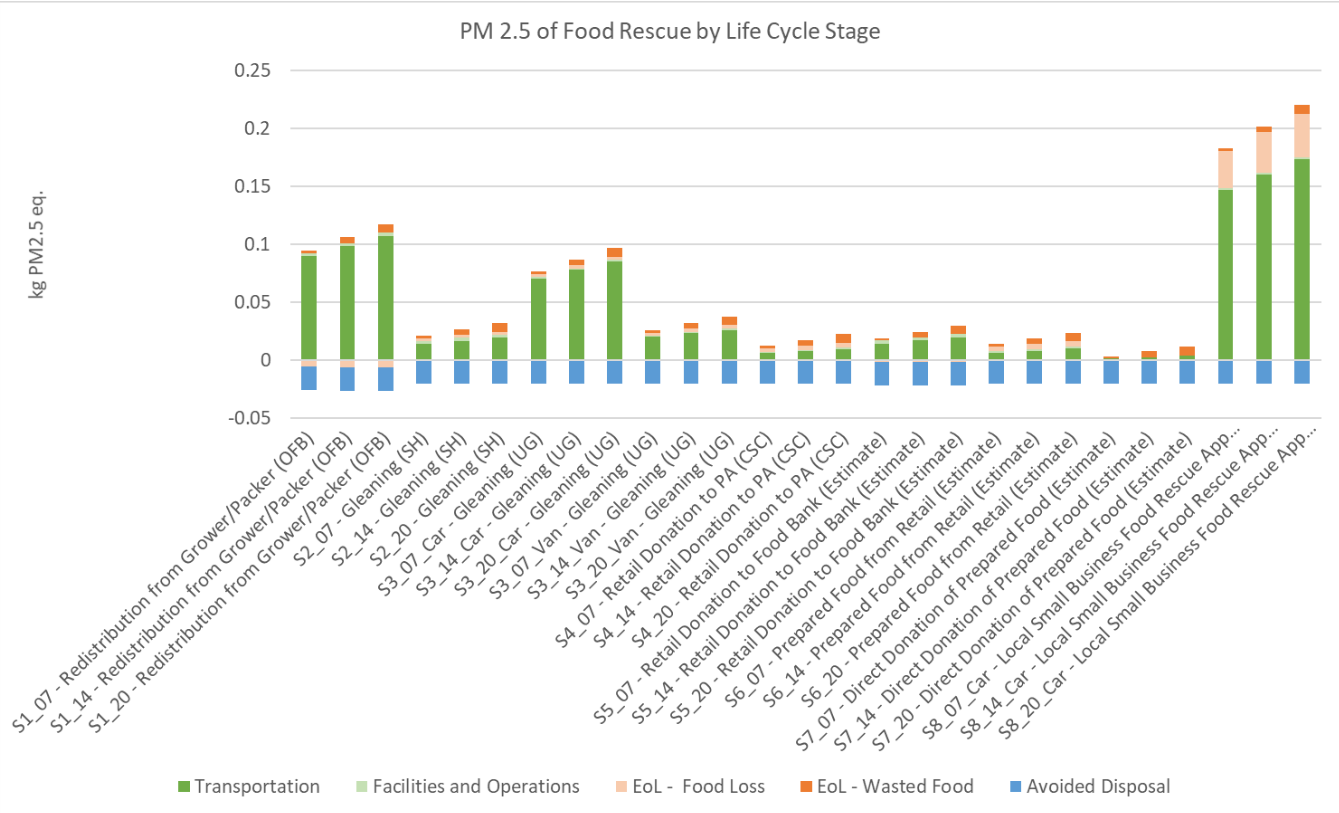

Figure 27 - PM2.5 by Life Cycle Stage for All Scenarios

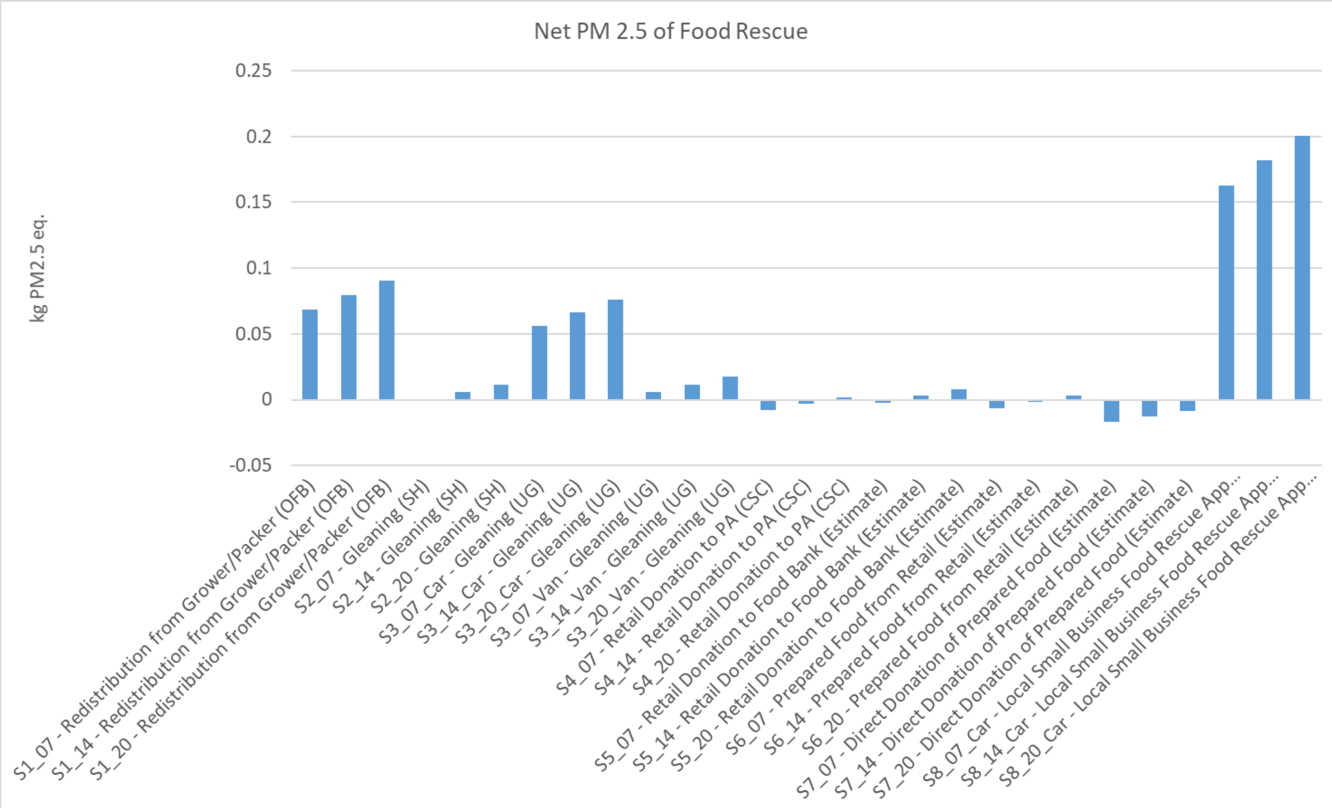

Figure 28 - Net PM2.5 for All Scenarios

5.1.1.7 Primary Energy Demand (PERNRT)

The results show that energy demand is primarily a function of transportation and the efficiency of a given transport mode in rescuing food. For example, Scenarios 3 and 8 both are based on car transport, a highly ineffecient mode of moving cargo. The most energy intensive mode of food rescue was scenario 8 where a high loss rate of rescued food caused the need for increased car travel to fulfill the functional unit. Other stages of the life cycle, such as facilities and operations or the avoided burdens of disposal, are inconsequential contributors to the energy demand results. Only one of the scenarios modeled had a potential energy demand that was negative and that was scenario 7. This implies that all other forms of food rescue evaluated require the consumption of energy, resulting in positive primary energy demand.

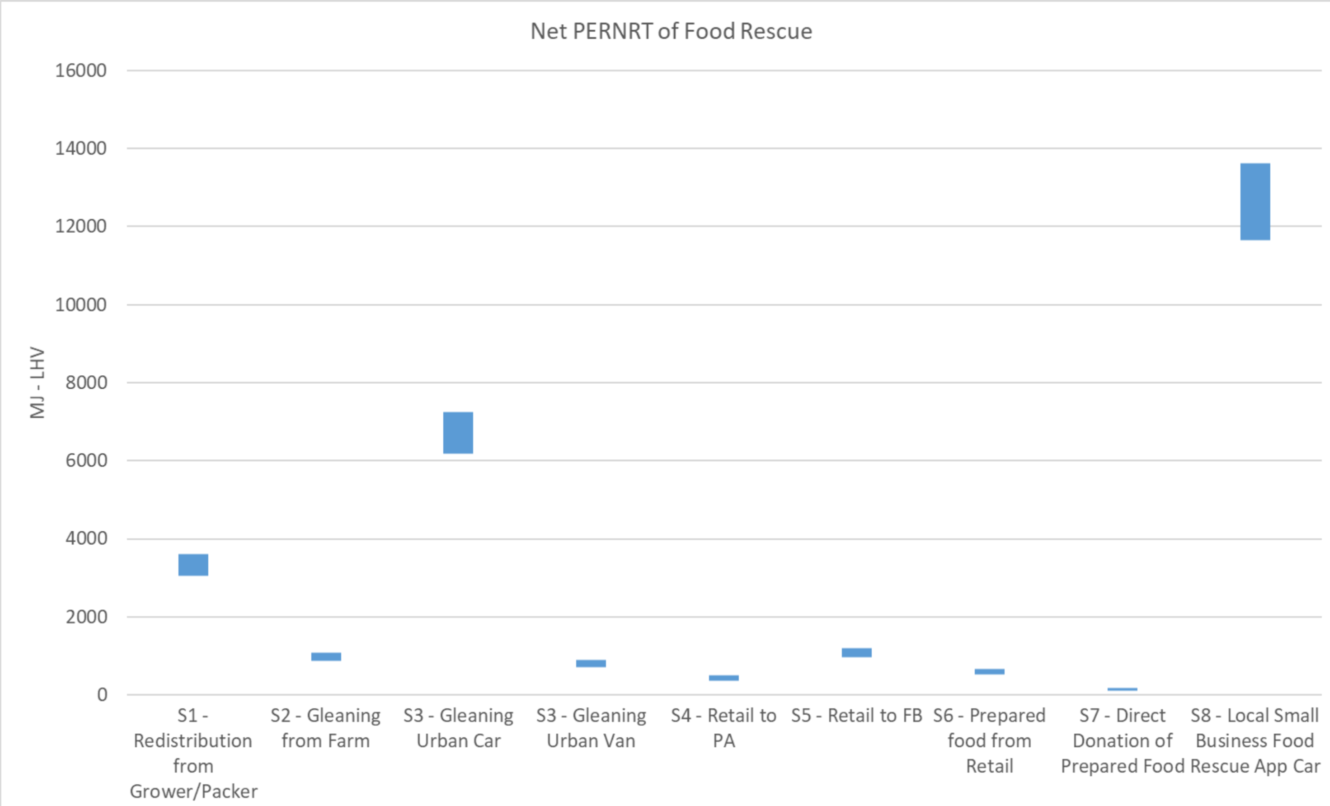

Figure 29 - Range of Net PERNRT (waste rates of 7-20 percent)

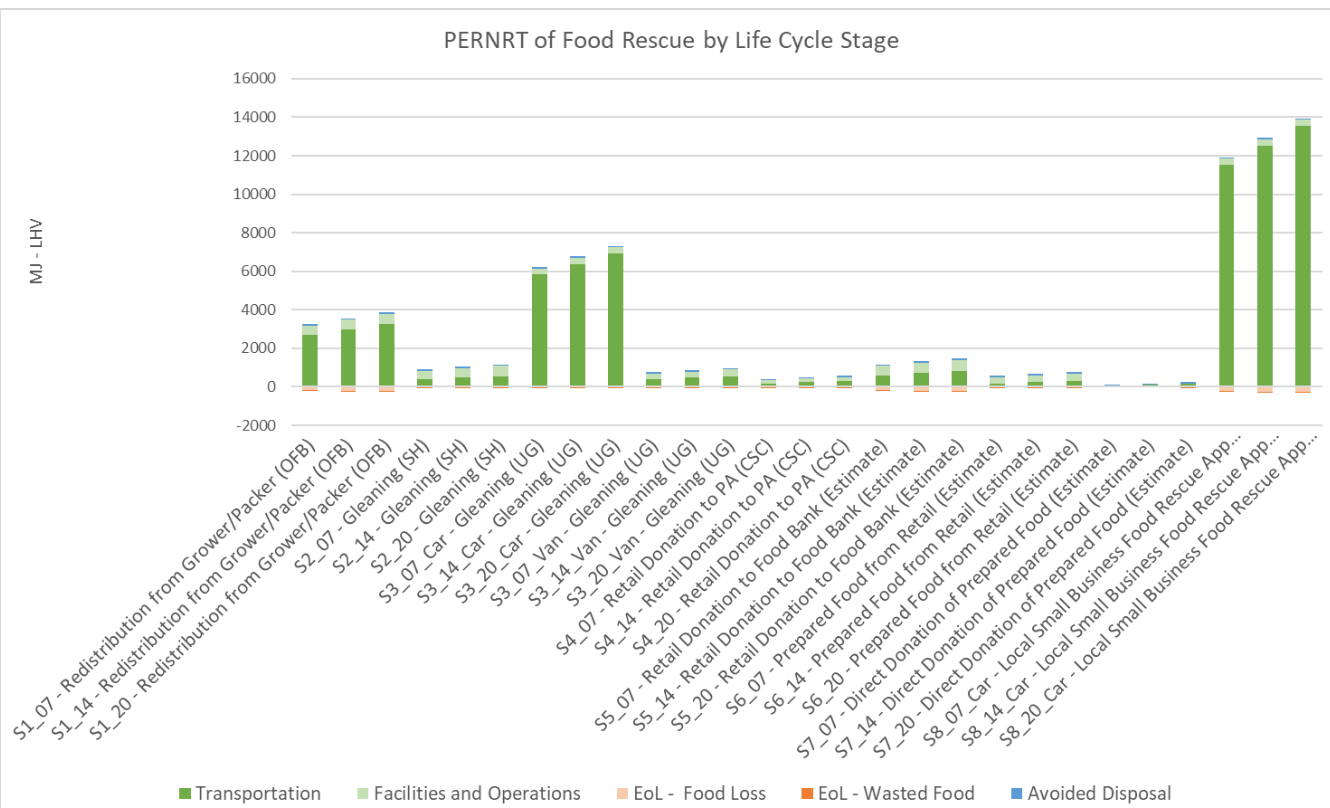

Figure 30 - PERNRT by Life Cycle Stage for All Scenarios

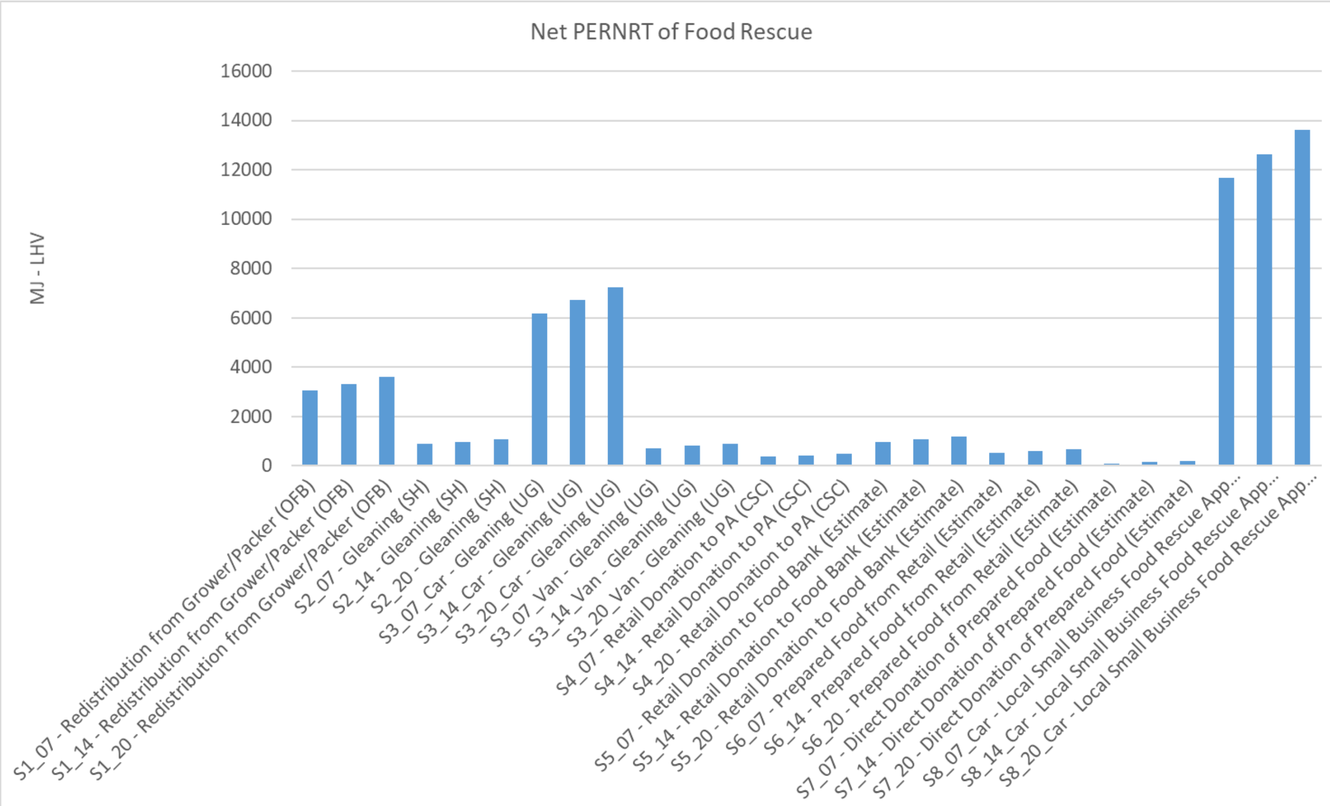

Figure 31 - Net PERNRT for All Scenarios

5.1.1.8 Blue Water Consumption

Results for the consumption of blue water follow a similar trend as other impact categories and indicators, in that the consumption values are highest for the least efficient mode of transporting cargo, which is car transport. This leads to the scenarios for gleaning (S3) by car and local small business food rescue (S8) demanding the most water. The overall water consumption is predominantly related to the transportation of rescued food, which includes all associated fuel inputs. To a lesser degree, facilities and operations contribute to blue water consumption and in the cases where transport is a negligible part of the rescue chain, such as for scenarios 2, 4, 5, 6, and 7, the facilities are the dominant contributor to water consumption.

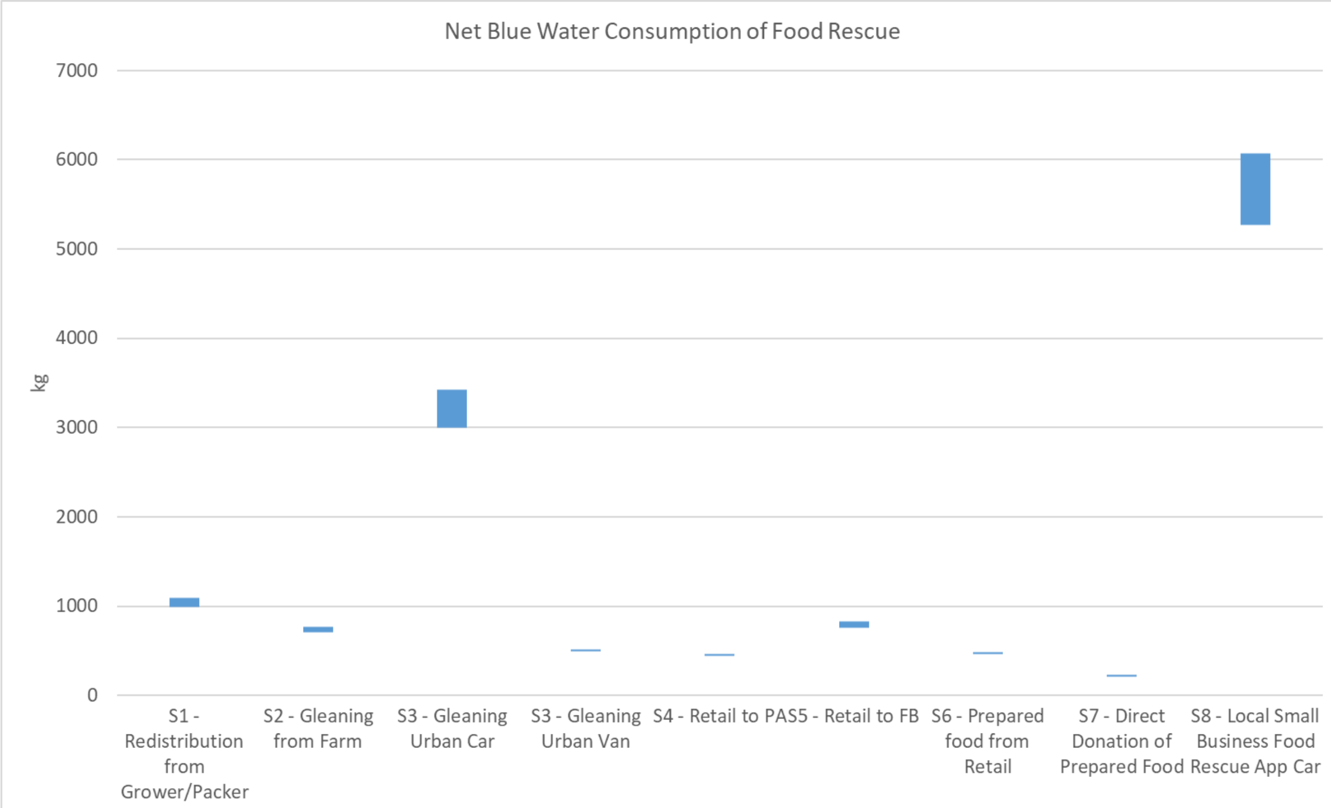

Figure 32 - Range of Net Blue Water Consumption (waste rates of 7-20 percent)

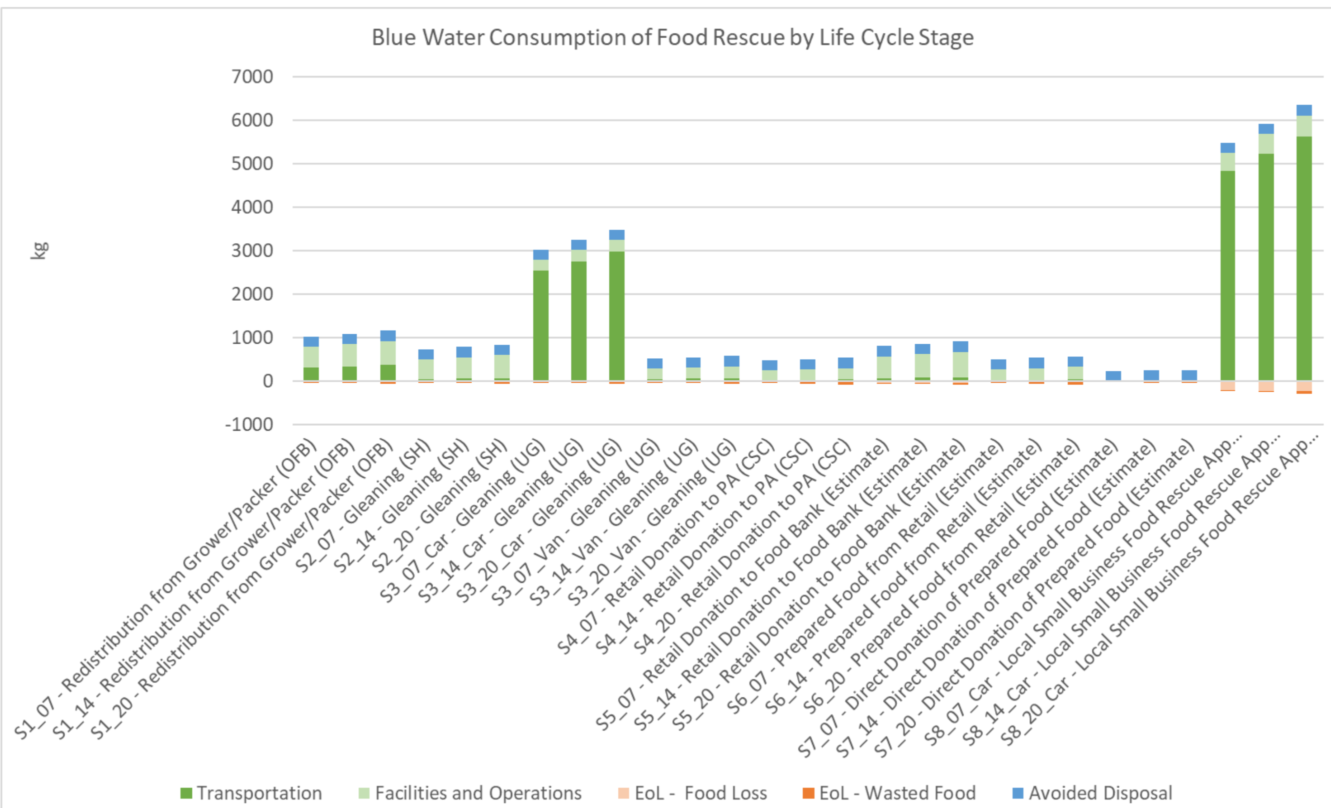

Figure 33 - Blue Water Consumption by Life Cycle Stage for All Scenarios

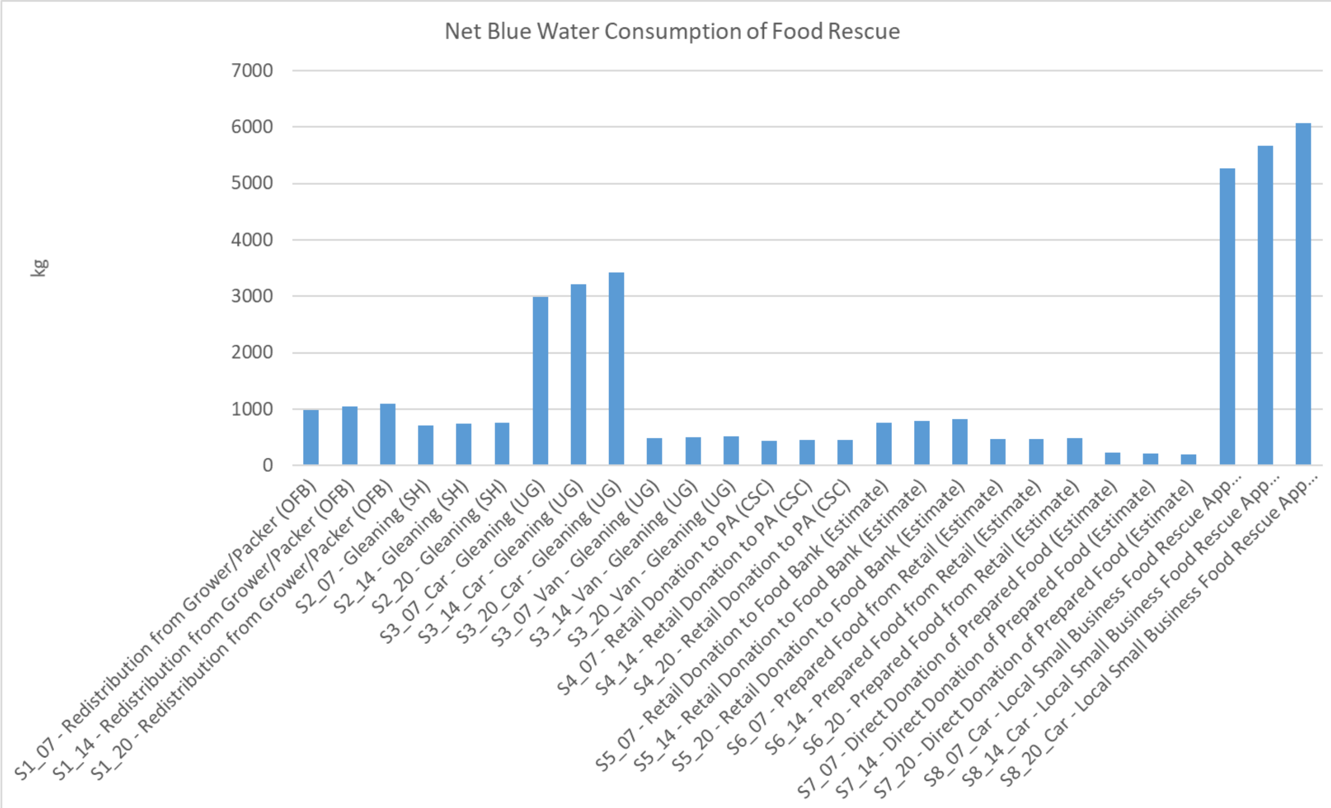

Figure 34 – Net Blue Water Consumption for All Scenarios

5.2 Break-Even Analysis for Wasted Food Rates

The amount of wasted food was determined to be a key variable in the resultant environmental impacts across all categories. Wasted food is defined herein as discarded food that is otherwise edible for human consumption. While some types of food rescue always lead to environmental impacts, even when accounting for the credit of avoided disposal, some led to an environmental benefit (net negative results). In the cases where a food rescue scenario led to environmental benefits for the default wasted food rates (7 percent, 14 percent, or 20 percent) this break-even analysis determined the percentage of wasted food that must occur for the benefits of a given food rescue pathway to become an impact. Put another way, the percentages of wasted food listed below show the point at which the impacts of all the food rescue activities (transport, facilities, and packaging) are equal to the credits of avoided disposal. If waste percentages exceed these break-even points, then the net result of the rescue activity is a burden to the environment.

Table 33 - Percent of Wasted Food where Impacts of Rescue Activities Equal Benefits of Avoided Disposal

Scenario Name	PERNRT	PENRT	PERT	EP	AP	GWP	PM2.5	ODP	SFP	Blue Water
S1 - Redistribution from Grower/Packer	-	-	-	57%	33%	8%	-	2%	-	-
S2 - Gleaning from Farm	-	-	-	65%	59%	42%	6%	-	25%	-
S3 - Gleaning Urban Car	-	-	-	57%	53%	-	-	-	0%	-
S3 - Gleaning Urban Van	-	-	-	65%	59%	44%	1%	-	22%	-
S4 - Retail to PA	-	6%	-	61%	57%	46%	17%	-	34%	-
S5 - Retail to FB	-	-	89%	51%	45%	30%	10%	-	15%	-
S6 - Prepared food from Retail	-	-	-	59%	56%	44%	16%	-	32%	-

S7 - Direct Donation of Prepared Food	-	30%	96%	76%	73%	64%	34%	2%	52%	-
S8 - Local Small Business Food Rescue App Car	-	-	-	-	-	-	-	-	-	-

Where no percentage is reported in a given cell (highlighted in red), there is never an environmental benefit associated with the food rescue scenario. It is always more impactful to expend the resources associated with rescue (transport, facilities and packaging) than the benefits of avoided disposal, even if all the rescued food is consumed (0 percent rate of wasted food). Additionally, those cells highlighted in red, that include a percentage, denote waste rates below 20 percent, which was the highest default wasted food rate in this analysis, but which is well below the global estimates of wasted food, which typically fall between 30-40 percent. Conversely, those cells highlighted in green show break-even percentages above 50 percent, which would exceed the high end of the global estimated range of food waste. Lastly, any cells in Table 33 that are shaded in yellow, reflect ranges of food waste which fall between 20-50%, roughly within the global average estimates for food waste.

6. Interpretation

6.1 Identification of Relevant Findings

A summary of key findings for this study are described below.

- The mode of transportation, and to a lesser degree distance, was a critical determinant in potential impacts for GWP, PM2.5, SFP, PERNRT and blue water consumption. Transportation was often the single largest contribution to the total impacts of each food rescue pathway, with passenger vehicle transport being the least efficient mode of transporting cargo.

- The amount of rescued food that turns into loss across the rescue chain or waste by the recipient is a significant driver in overall life cycle impacts. This is due mainly to the additional transportation required to fulfill the function defined in the study (1000 kg of food rescued and consumed), but secondarily due to the increased direct emissions of disposal associated with lost or wasted food.

- The relevance of the avoided disposal credit varied depending on the impact category and scenario in question. It was a small contributor to potential life cycle impacts for S1, S3, and S4, and large contributor for all other scenarios, when looking at GWP, PM 2.5 and SFP. Avoided disposal was a significant contributor (credit) to all scenarios in terms of AP and EP. Avoided disposal provided virtually no benefits in terms of blue water consumption, PERNRT, and ODP. Thus, the conventional belief that because food recuse diverts food from a landfill it is always a good thing for the environment does not necessarily hold. Instead, avoided disposal has limited potential to reduce life cycle environmental impacts and that potential is varied.

- The impacts of facilities and operations associated with rescue were consistently a small contributor to the overall life cycle for the majority of impact categories (PERNRT, EP, AP GWP, PM 2.5, ODP, and SFP). Though for Blue Water Consumption, facilities and operations did actually contribute the largest share of total impacts for a subset of scenarios (S2, S3 Van, S4, S5, and S6)

- End-of-life disposition (landfill, aerobic composting, incineration or anaerobic digestion) was often a small contributor to life cycle impacts across all categories. However, it became meaningful for instances where a high loss rate was assumed as in Scenario 8.

Overall, the findings of this analysis can be used to provide directional understanding of the relevance of different processes along the food rescue chain. The findings are limited by the accessibility of primary data from food rescue organizations, which is not surprising, as these organizations do not often have staff or resources to implement robust data management systems. The study has also not undergone third party critical review as described by the ISO standards.

The sensitivity analysis in Appendix A includes the upstream production and distribution in the analysis, which provides another layer of understanding, namely by placing rescue in the context of the total life cycle impacts of the food system. In most cases, we saw that food rescue activities comprise a very small portion of the total lifecycle impacts of foods. Production of foods dominated impacts, which suggests that when considering the upstream costs of food production, a true waste prevention strategy is the most environmentally beneficial pathway for avoiding food impacts. Unlike focusing just on waste reduction or diversion, prevention explicitly addresses, and seeks to reduce, impacts across the full life cycle – on-farm, at processing, at retail, and so on. Thus, true waste prevention has the potential to reap the greatest environmental benefits.

6.2 Data Quality Assessment

The quality of the data used to develop the life cycle inventory is assessed in four ways: precision, completeness, consistency and representativeness. The four subsections below correspond to these data quality indicators.

To cover these requirements and to ensure reliable results, this study sought to capture primary data from stakeholders. However, primary data was not readily available (see 3.9 for details on limitations in acquisition of primary data) for all rescue scenarios and so was supplemented with secondary data.

Primary industry data in combination with consistent background LCA information from GaBi and Ecoinvent were used.

6.2.1 Precision and completeness

- **Precision:** Foreground data is primary data or modeled based on primary information sources from various food rescue stakeholders; no superior precision is attainable within this project. To account for potential variability in rescue pathways over time, data was collected and averaged over the given annual study period. In instances where primary data were not available for a specific rescue scenario, appropriate primary data from other scenarios was coupled with qualitative information from stakeholders to derive estimates. All background data is GaBi or Ecoinvent data, both of which include documentation regarding the inherent precision**.**
- **Completeness:** Each unit process was checked for mass balance and completeness of the emission inventory. No data was intentionally omitted. To address the potential incongruity caused of the system boundary beginning at the point of rescue, a sensitivity analysis was performed (see Appendix A – Sensitivity Analysis). This incongruity comes from the sunk costs invested in upstream production of a given food item, which increase the further along the supply chain that the food rescue intervention occurs (e.g., rescuing apples from a tree vs apple juice from a retail store).

6.2.2 Consistency and reproducibility

- **Consistency:** In an effort to ensure consistency, all primary data were collected with the same level of detail, when possible. All background data were sourced from the GaBi or Ecoinvent databases. Allocation and other methodological choices were made consistently throughout the model, such as the handling of avoided burdens via system expansion.
- **Reproducibility:** Reproducibility is a function of transparency and to the greatest degree possible full disclosure of input-output data, dataset choices, and modeling approaches are in this report. Based on this information, a third party with access to comparable LCI databases and tools should be able to approximate the results of this study using the same data and modeling approaches.

6.2.3 Representativeness

- **Temporal:** All primary data were collected for the year 2015. All secondary data comes from the GaBi 6 2016 databases and are representative of the years 2010-2016. As the study intended to compare the systems for the reference year 2015, temporal representativeness is warranted.
- **Geographical:** All primary and secondary data were collected specific to the countries / regions under study (US / Oregon). Where country / region-specific data were unavailable, proxy data were used (see chapter 4.10). Geographical representativeness is considered to be moderate to high.

- **Technological:** All primary and secondary data were modeled to be specific to the technologies or technology mixes under study. Where technology-specific data were unavailable, proxy data were used (see chapter 4.10). Technological representativeness is considered to be high.

6.3 Completeness, Sensitivity, and Consistency

6.3.1 Completeness

All relevant process steps for each product system were considered and modeled to represent each specific situation. The process chain is considered sufficiently complete with regard to the goal and scope of this study.

6.3.2 Sensitivity

Sensitivity analyses were performed to test the robustness of the results towards uncertainty and main assumptions. Detailed results can be found in Appendix A – Sensitivity Analysis.

6.3.3 Consistency

All assumption, methods and data were found to be consistent with the study's goal and scope. Differences in background data quality were minimized by using LCI data from the GaBi and Ecoinvent. System boundaries, allocation rules and impact assessment methods have been applied consistently throughout the study.

6.4 Conclusions, Limitations, and Recommendations

6.4.1 Conclusions

The environmental impacts of the food rescue pathways explored within this study showed a few clear trends. First, the mode and distance of transport employed to rescue food are critical determinants of overall life cycle impacts when considering a system boundary that begins at the point of rescue. Second, the amount of food wasted by the recipient or lost across the rescue chain had cascading effects. More loss and waste resulted in more rescue activities being required upstream and more disposition activities for wasted food, all of which increased overall life cycle impacts. This second finding held true both when considering a system boundary that begins at the point of rescue, but also when adding in the sunk costs and upstream food production impacts. Third, the overall benefits of avoided disposal of the functional unit was an important part of the life cycle for some but not all impact categories and scenarios. The benefits of avoided disposal were also proportionally lower when the total overall waste and loss rates increased all the upstream impacts.

When impacts from the full life cycle, including production impacts, are considered, as done in Appendix A – Sensitivity Analysis, the overall rescue activities become a small fraction of the total life cycle impacts of making and distributing the food in the first place. This is the result of the high impacts associated with production. The impacts of upstream production of foods varies widely depending on the type of food. Chicken had the highest impacts of the three food items added to the system boundary for the sensitivity analysis and dominated all other rescue activities—increasing overall net impacts by between 3 – 120 fold, depending on the scenario and impact category. Milk had the next highest contributions to net impacts; again increasing overall net impacts multiple times. Apples did increase the overall impacts across impact categories, but to a much lesser degree, typically by doubling them.

In terms of life cycle stages that were less important, facility operations and repackaging of rescued food tended not to have a significant influence on total life cycle impacts across all categories. Overall, disposal of wasted or lost food made a relatively small contribution to overall life cycle impacts, though was influenced by the amount of wasted or lost food sent to disposal.

Finally, it is important to bear in mind that food rescue is fundamentally about feeding people. Hunger relief organizations must employ a variety of strategies to meet their clients' needs. Each of the scenarios modeled within this study plays a different role in fulfilling the needs of the community. The environmental lens in this LCA provides a different view that food rescue organizations can use when evaluating how to meet community needs. Understanding the environmental impacts can help ensure that food rescue organizations consider the least impactful means for retrieving food. If there is a need in the community for prepared foods, for example, but sourcing that food is both environmentally burdensome and financially costly, perhaps the hunger relief organization may seek other ways to meet that need.

6.4.2 Limitations & Assumptions

A full reporting on the assumptions and limitations of this study is in Section 3.9 above. Generally, the study is limited primarily due to access to primary data, and the assumptions regarding key parameters are disclosed and tested through a combination of scenario and sensitivity analysis.

6.4.3 Recommendations

Based on findings of this analysis DEQ recommends some courses of action that could reduce the environmental impacts of food rescue:

- **Rescue foods that are most likely to be consumed.**
    - Expending time and effort to rescue food that ultimately ends up being lost or wasted is for naught. Even worse, that time and effort comes with added environmental impacts. Rescuing every potentially edible food item otherwise destined for waste would lead to increased environmental impacts for the food system.
    - Consider focusing on pantry staples and commonly known ingredients. Ensure ingredients are consistent with the cultural needs of recipients.
- **Rescue foods using the most efficient mode of transport and from as close to recipients as possible.**
    - Transporting food in personal motor vehicles, like cars, proved to be the least efficient, and most impactful, means of rescue.
    - To a lesser degree, traveling vast distances in order to rescue food also increased the impacts of food rescue, even if done with a relatively efficient means of cargo transport such as a large class 8 truck.
- **As a general rule, start with preventing the wasting of food (i.e., source reduction) when considering higher order goals related to environmental and social outcomes.**
    - Preventing the loss or wasting of food in the first place avoids environmental impacts before they happen.
    - If food is otherwise destined to be wasted, rescue it using the most efficient (and least environmentally impactful) means possible for human consumption.
        - Consider the nutritional value of the items being rescued, prioritizing to meet nutritional requirements.
        - Consider the economic costs of the chosen rescue pathway for a given food item.
        - Consider the relative impacts of upstream production in selecting food to rescue.
        - Consider community need and capacity – what is truly lacking in a community, what is community expressing need of, and what does a community already have access to.

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8. Appendix A – Sensitivity Analysis

For the results presented in the sensitivity analysis, the system boundary of this study (shown in Figure 35). It includes the cradle-to-gate production impacts of three generic food items (arbitrarily selected are chicken, milk, and apples), any upstream sunk costs (e.g. transport or warehousing) required up to the point of food rescue, all transport from the point of rescue to people, packaging (specifically added for rescue), warehousing, refrigeration, energy/fuel use, any losses/spoilage/scrap throughout, and final disposition. Final disposition includes scenarios where rescued food is either composted or landfilled when not eaten and instead is ultimately wasted. The boundary ends at the point where the food is given to a person and a credit is calculated for the avoided burdens of disposal, which would have occurred, had the food not been rescued. All results show this credit as a separate informational item, meaning that results are shown with and without this credit included.

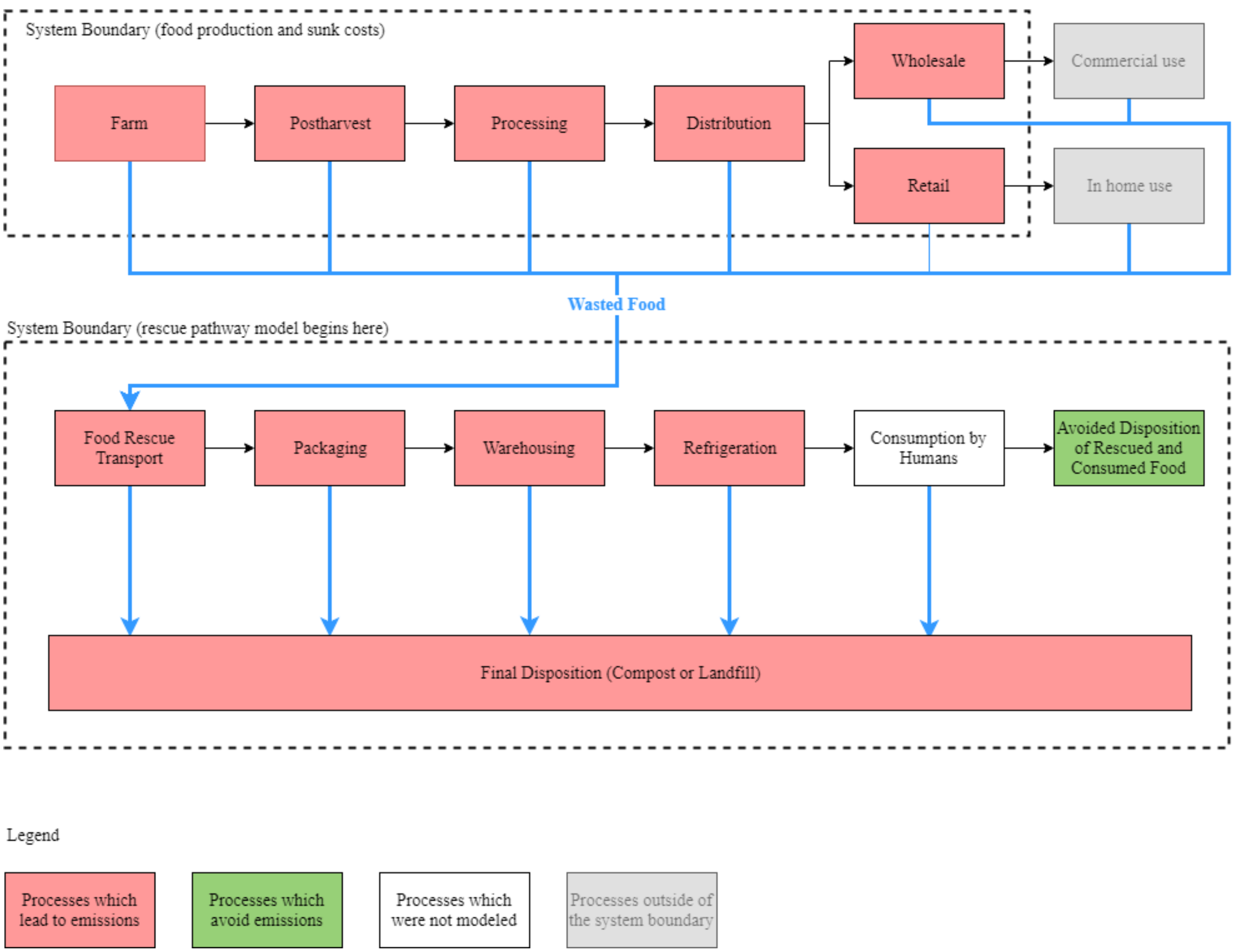

Figure 35 - System Boundary of Product System

8.1 Food Rescue Results

The following subsections contain results for all food rescue scenarios broken down by each reported impact category or indicator. For each subsection, there are six plots. The first two charts pertain to scenarios of chicken production, the next two milk and the last two apples. Unlike the results shown in the body of the report, the results of this sensitivity analysis include upstream production and estimated sunk costs, in addition to the other life cycle stages previously included in the system boundary.

8.1.1 Global Warming Potential (GWP)

The LCIA results for GWP show the inclusion of upstream production of food is now a dominant contributor to life cycle emissions of a given scenario. The magnitude of the increased impacts correlates with the type of food. Chicken production is most impactful, followed by milk, and then apples. Sunk costs do increase GWP but only marginally for the scenarios where they apply. Overall, the relative impacts across each scenario do not lead to significantly different conclusions. No scenarios result in a net negative GWP when production is included, a finding that holds true for all three foods analyzed.

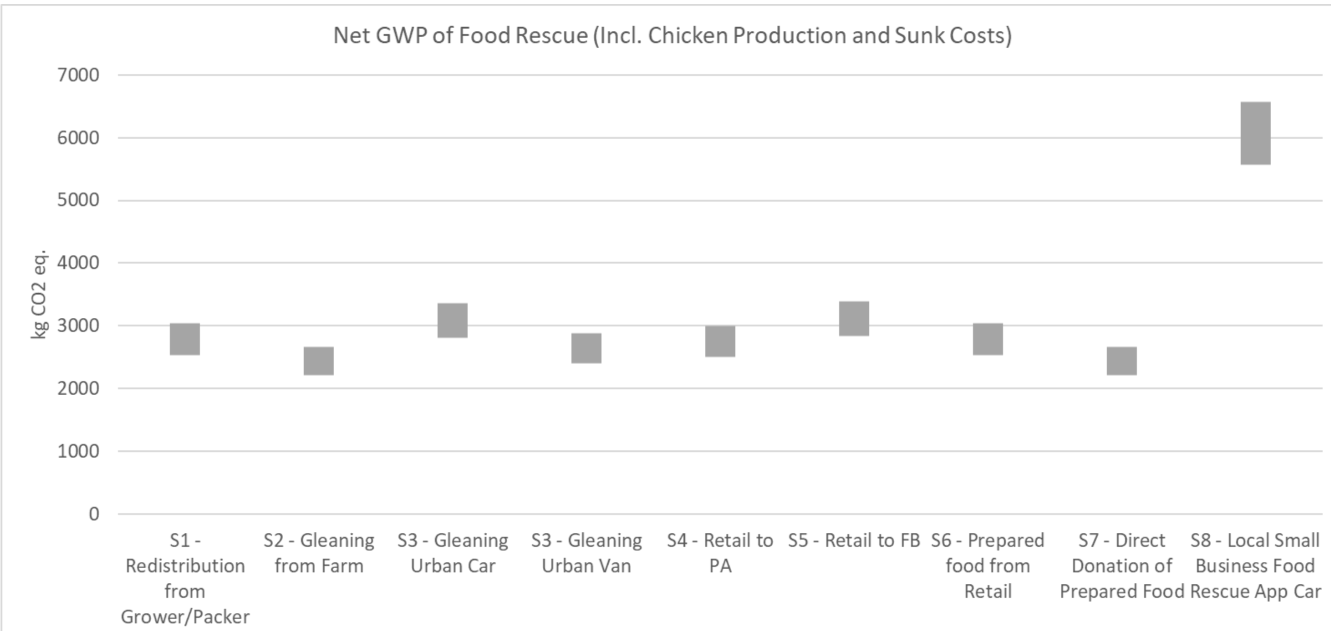

Figure 36 - Range of Net GWP for All Rescue Scenarios including Upstream Production of Chicken and Sunk Costs

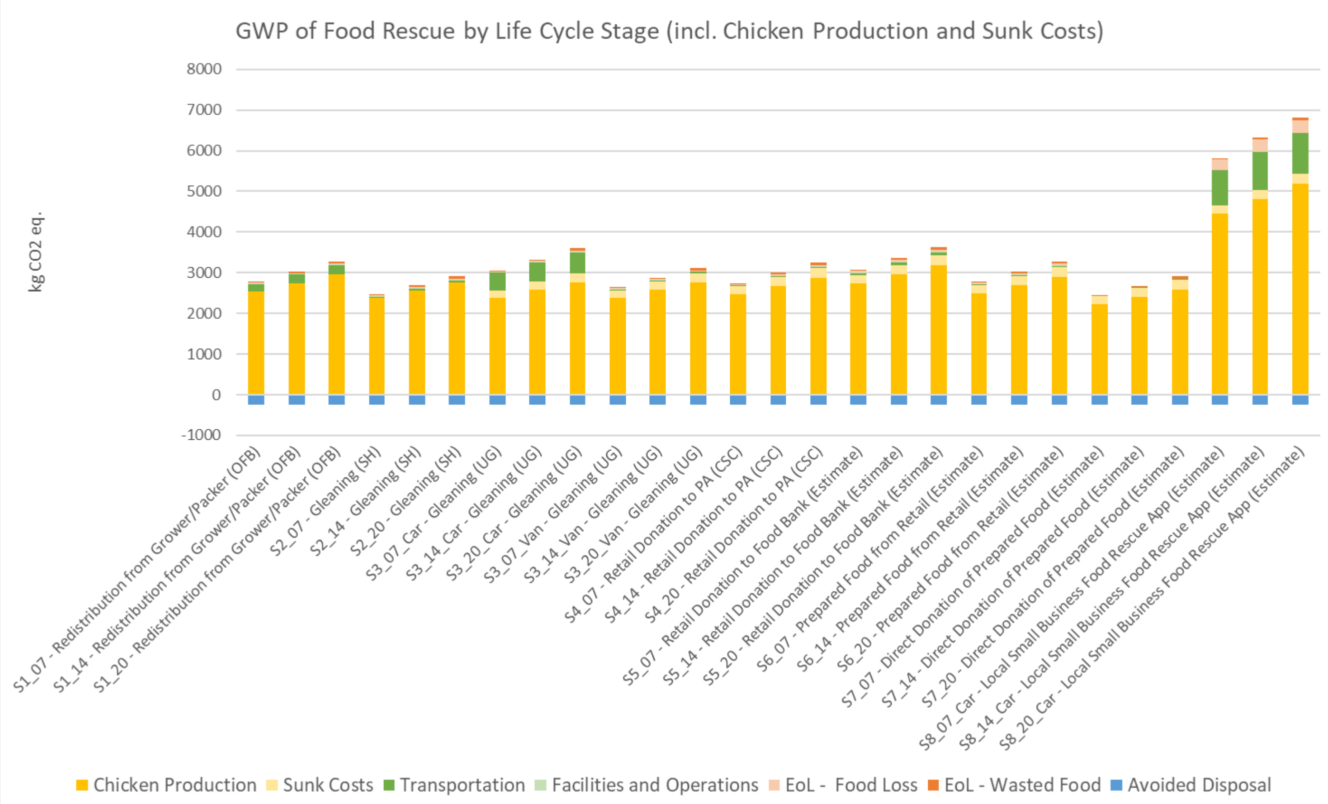

Figure 37 - GWP by Life Cycle Stage for All Scenarios including Upstream Production of Chicken and Sunk Costs

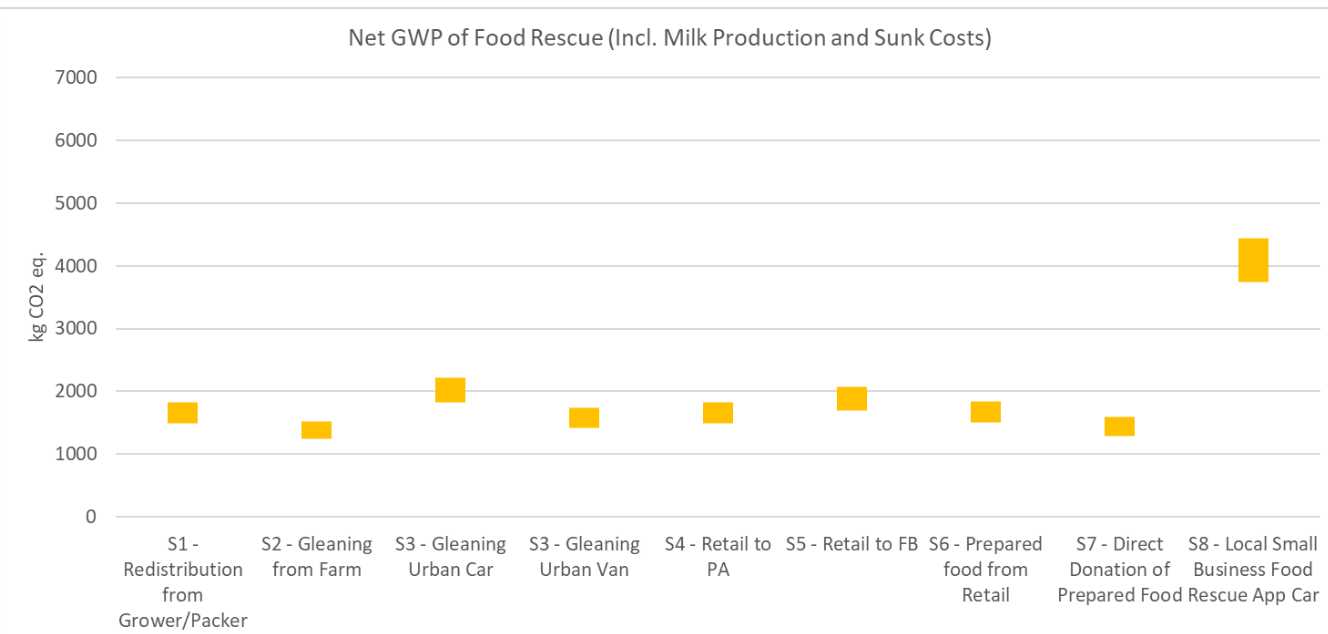

Figure 38 - Range of Net GWP for All Rescue Scenarios including Upstream Production of Milk and Sunk Costs

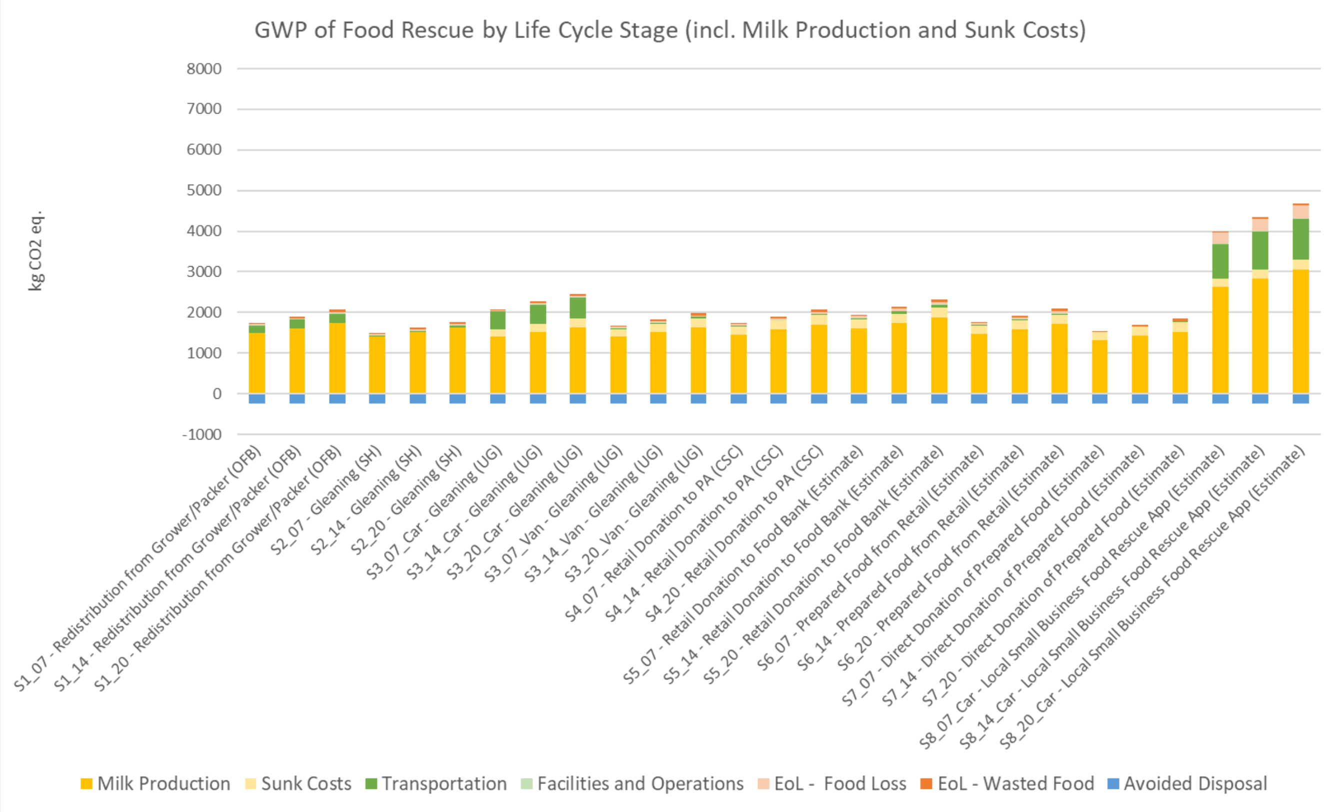

Figure 39 - GWP by Life Cycle Stage for All Scenarios including Upstream Production of Milk and Sunk Costs

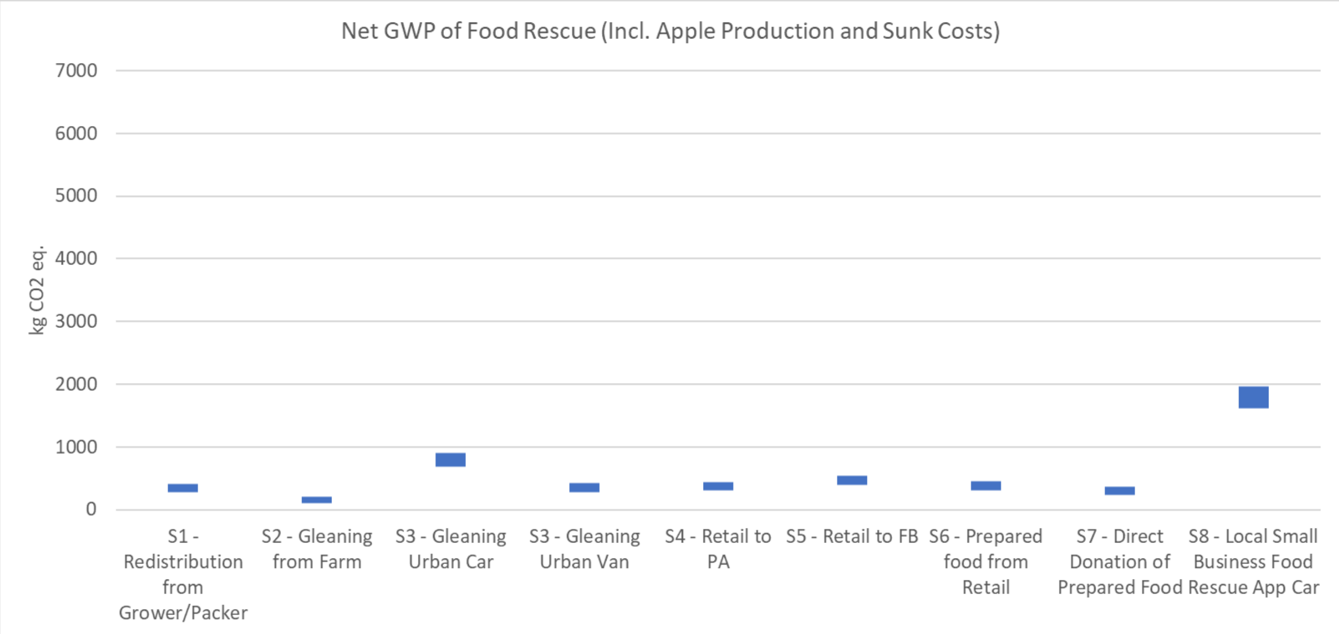

Figure 40 - Range of Net GWP for All Rescue Scenarios including Upstream Production of Apples and Sunk Costs

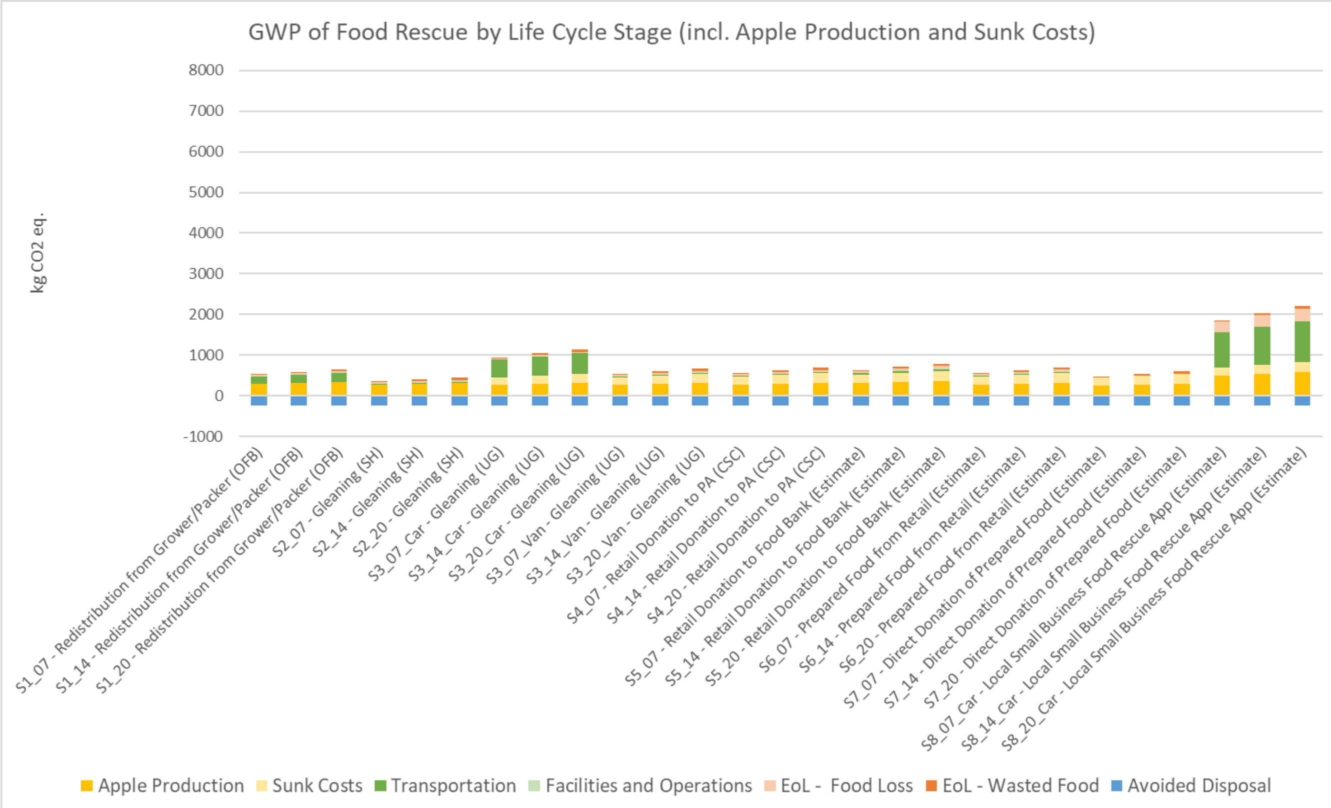

Figure 41 - GWP by Life Cycle Stage for All Scenarios including Upstream Production of Apples and Sunk Costs

8.1.2 Eutrophication Potential (EP)

The release of eutrophic compounds is now a function primarily of upstream food production. Formerly, disposal played a large part in effecting EP, but not so when upstream impacts are included. The rate of loss and wasted food plays a primary role in the variation of overall EP, with higher loss/waste rates leading to increased eutrophication (a result of the need to produce more and still deliver the same function of 1000 kg of food rescued and consumed). The same trend as observed with GWP shows up here, with chicken increasing EP the most, then milk and then apples. One outcome that is consistent with the main analysis is that Scenario 8 leads to the highest EP because of the high loss rate for rescued food assumed in that scenario. Here too, no scenarios result in a net negative EP.

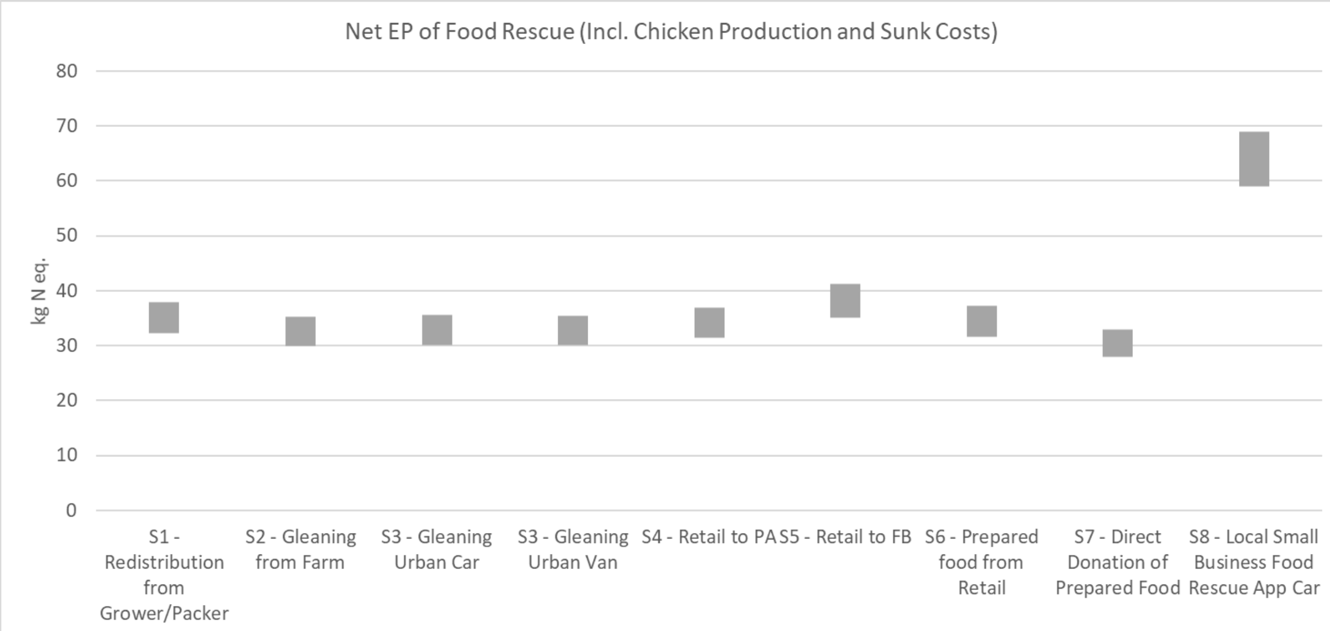

Figure 42 - Range of Net EP for All Rescue Scenarios including Upstream Production of Chicken and Sunk Costs

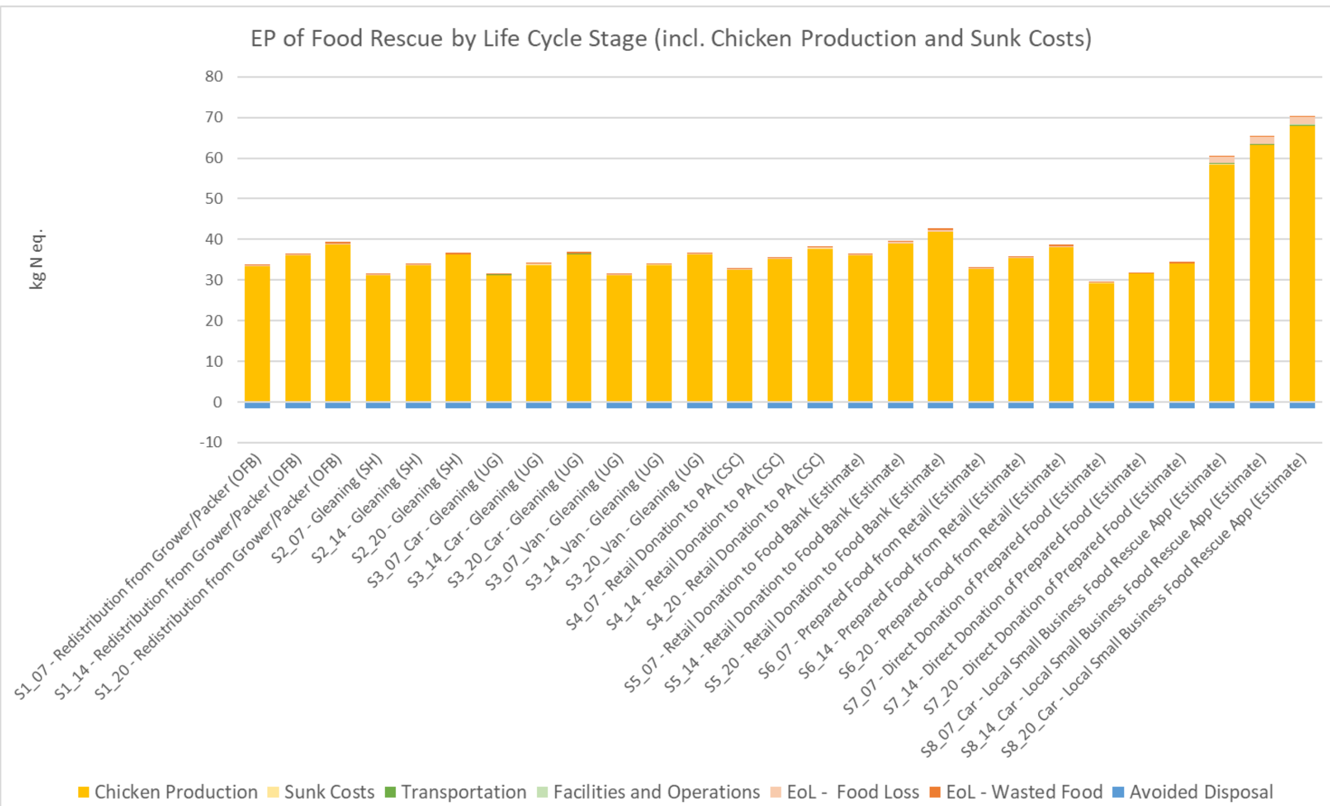

Figure 43 - EP by Life Cycle Stage for All Scenarios including Upstream Production of Chicken and Sunk Costs

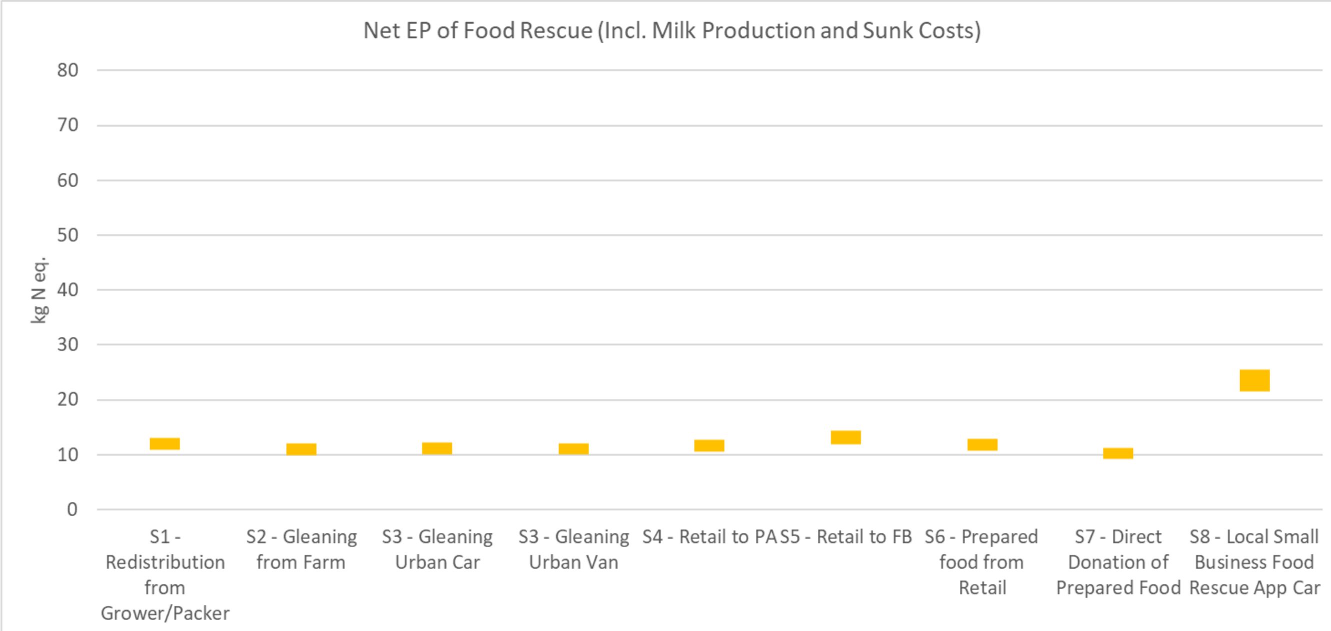

Figure 44 - Range of Net EP for All Rescue Scenarios including Upstream Production of Milk and Sunk Costs

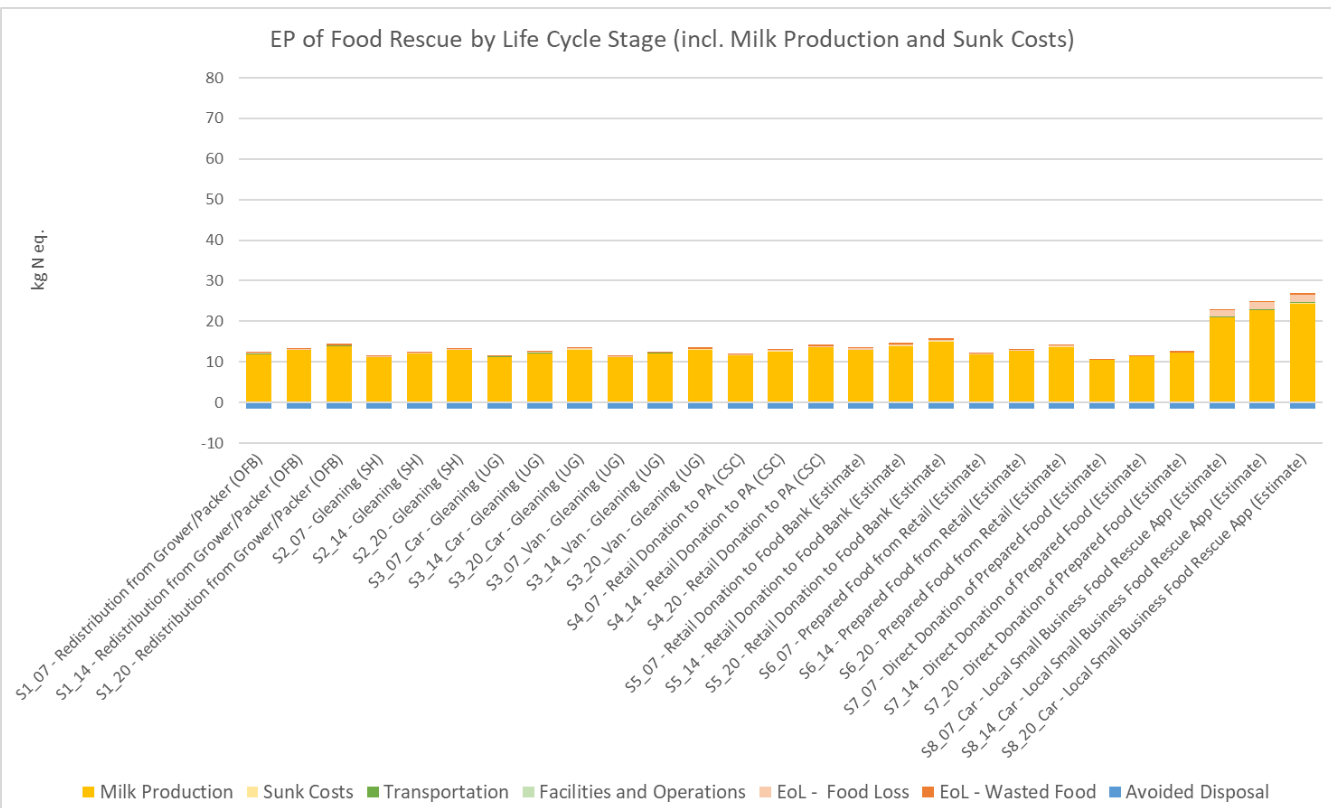

Figure 45 - EP by Life Cycle Stage for All Scenarios including Upstream Production of Milk and Sunk Costs

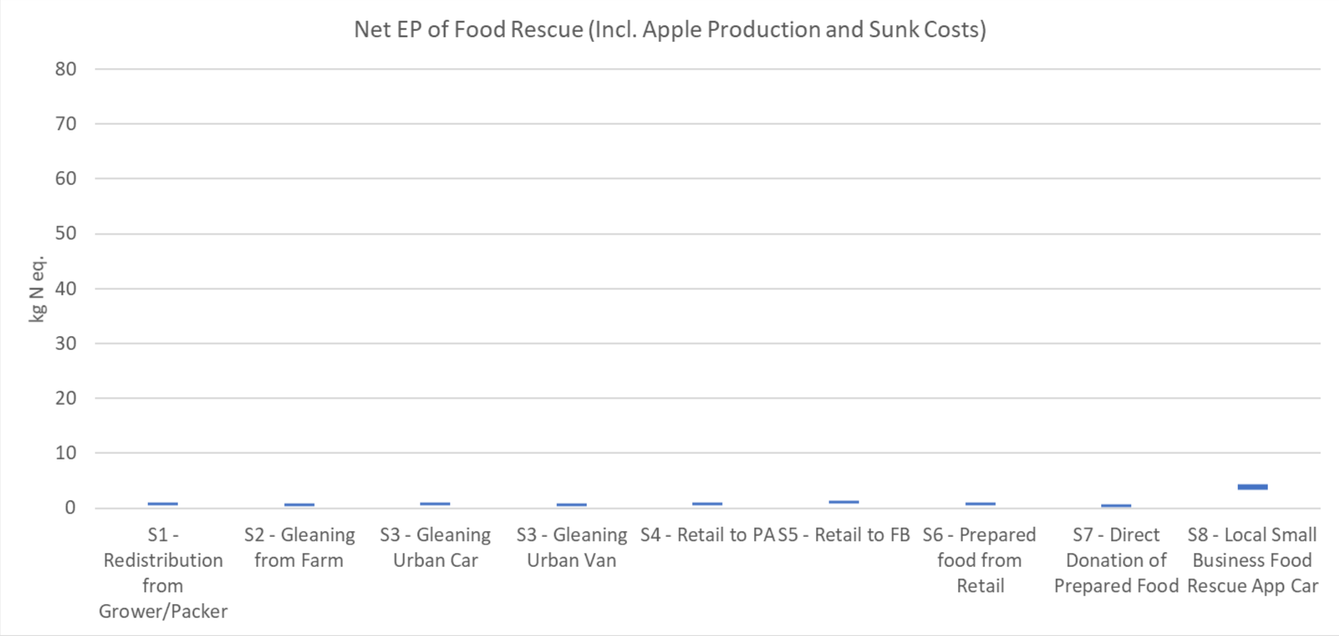

Figure 46 - Range of Net EP for All Rescue Scenarios including Upstream Production of Apples and Sunk Costs

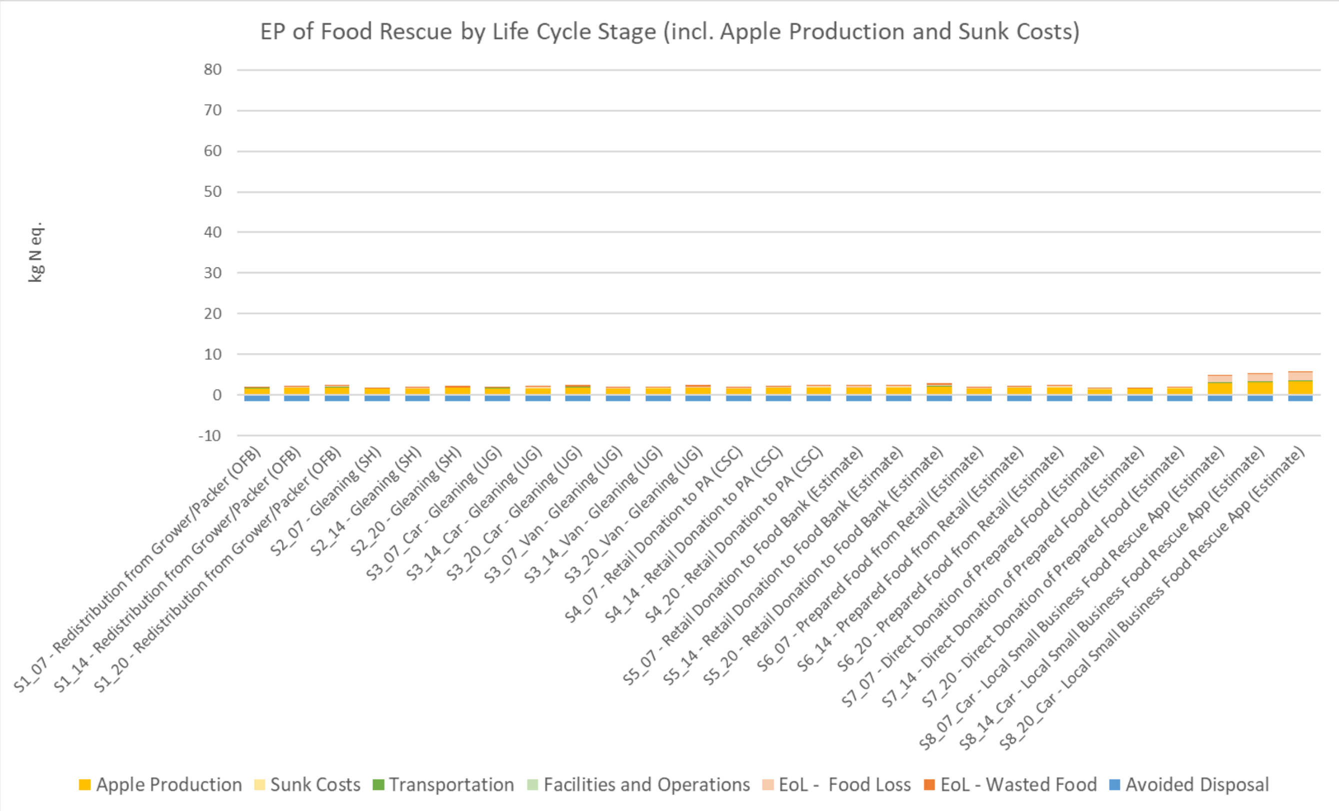

Figure 47 - EP by Life Cycle Stage for All Scenarios including Upstream Production of Apples and Sunk Costs

8.1.3 Acidification Potential (AP)

The release of acidifying compounds is principally now a function of upstream production of foods. Chicken leads to the largest amount of AP, followed by milk and apples. Here again there is not a significant shift in the overall conclusions across scenarios. Scenario 8 leads to the highest AP because of the high loss rate for rescued food assumed in that scenario that drives an increase in upstream production to fulfill the functional unit. There are a few instances that result in net negative AP, namely scenario 2 and 7 where apple production is modeled for the upstream food production. For all other scenarios and foods though, the inclusion of upstream production and sunk costs results in positive (e.g., burdens) AP results.

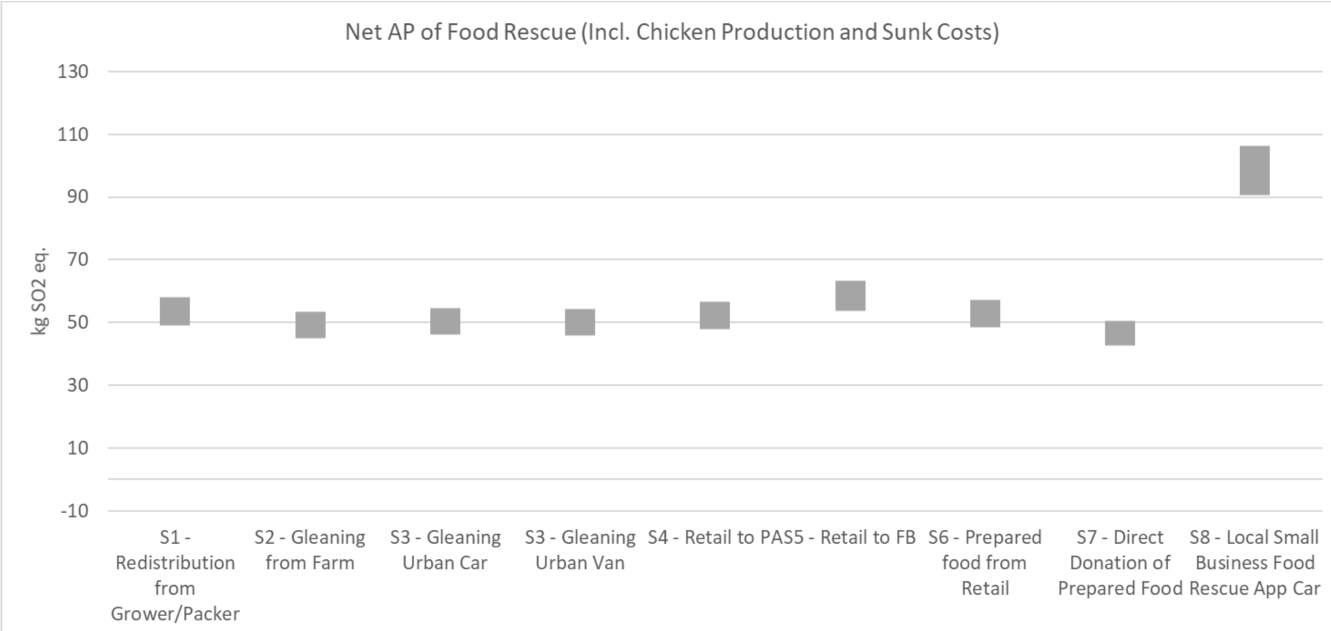

Figure 48 - Range of Net AP for All Rescue Scenarios including Upstream Production of Chicken and Sunk Costs

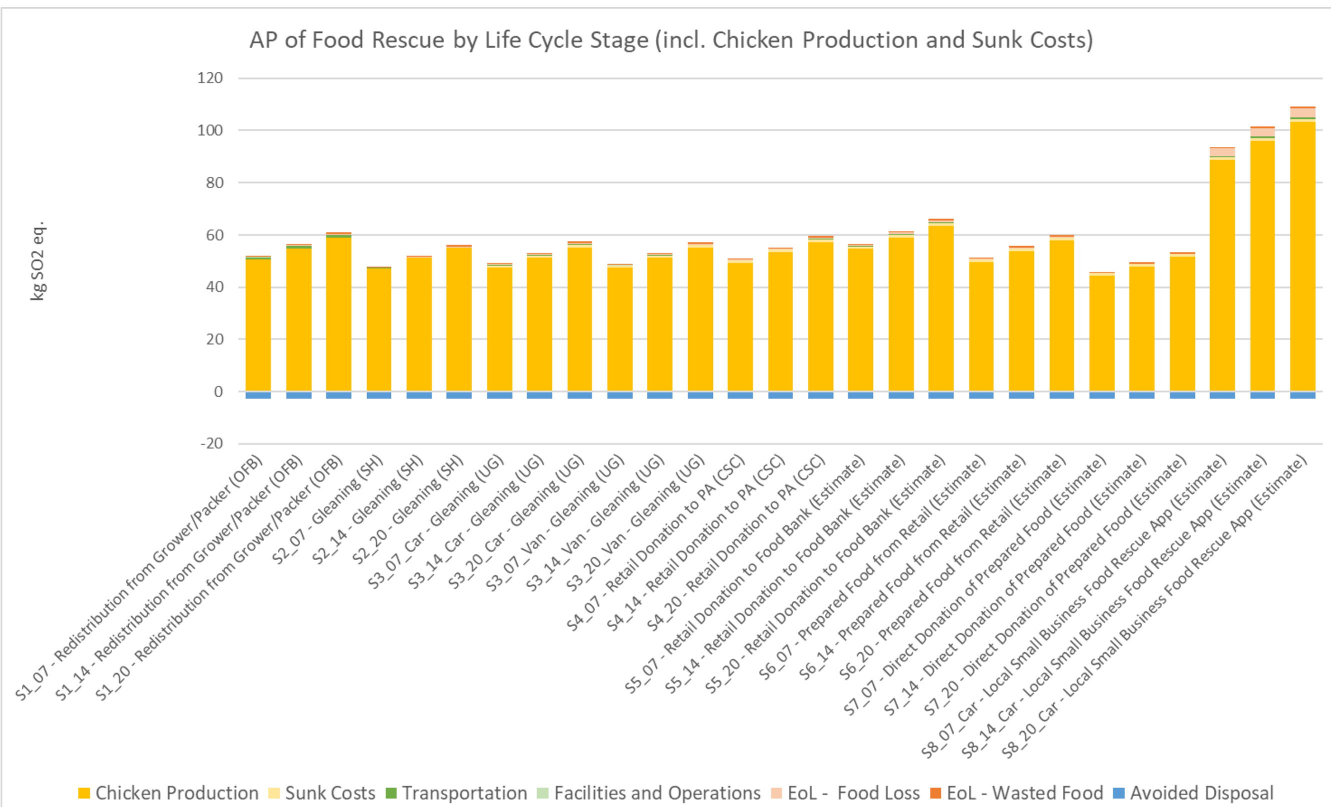

Figure 49 - AP by Life Cycle Stage for All Scenarios including Upstream Production of Chicken and Sunk Costs

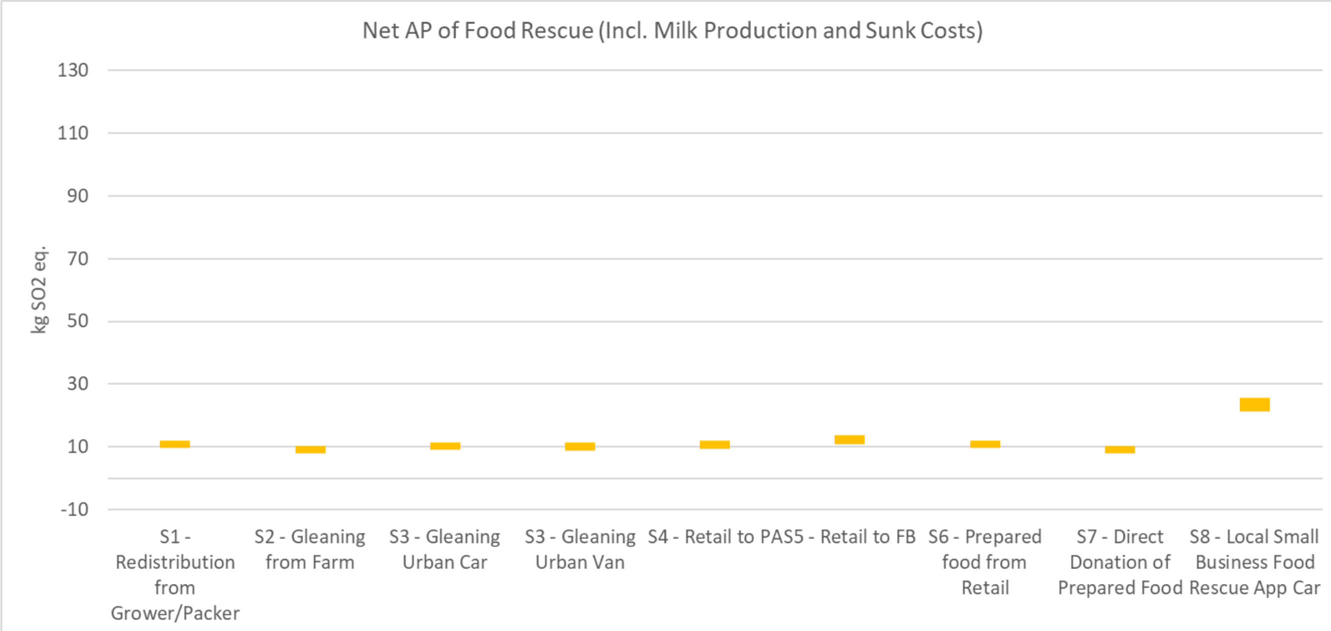

Figure 50 - Range of Net AP for All Rescue Scenarios including Upstream Production of Milk and Sunk Costs

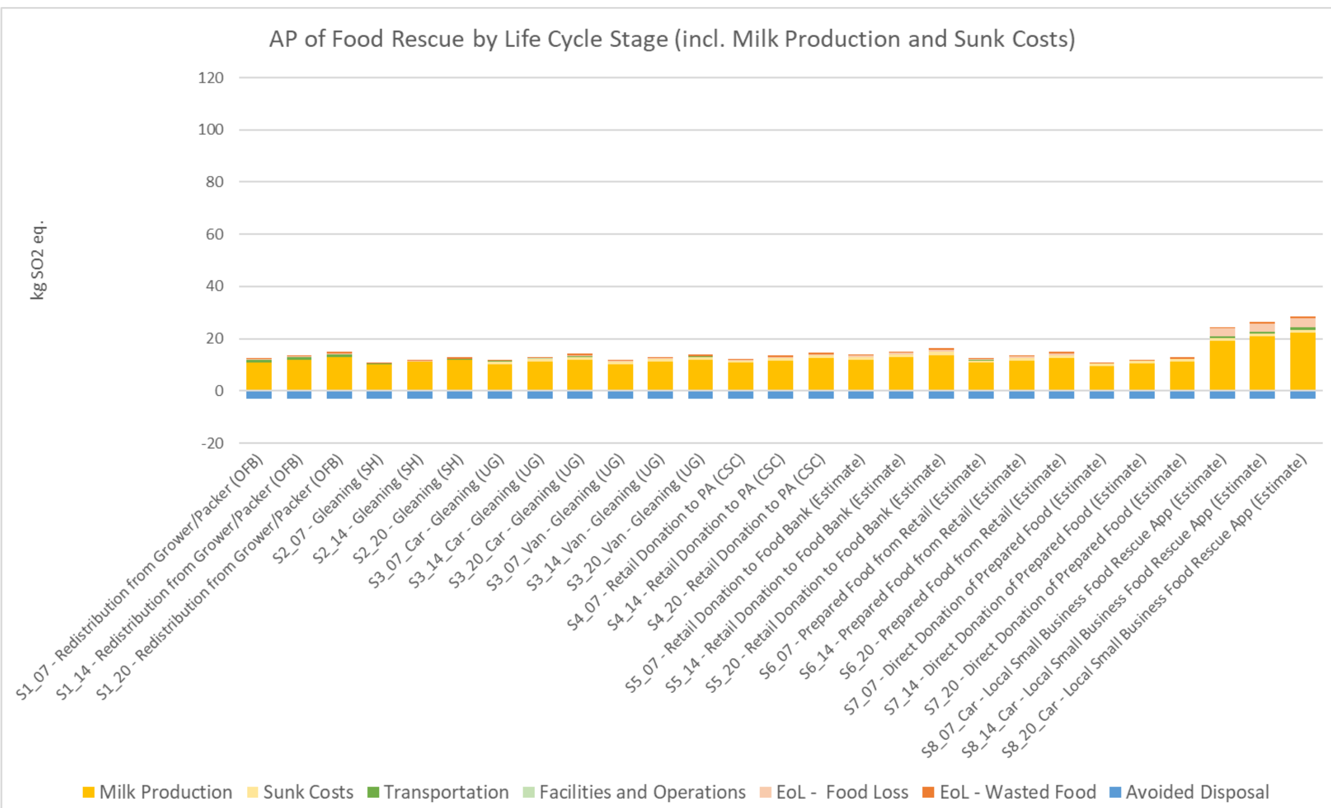

Figure 51 - AP by Life Cycle Stage for All Scenarios including Upstream Production of Milk and Sunk Costs

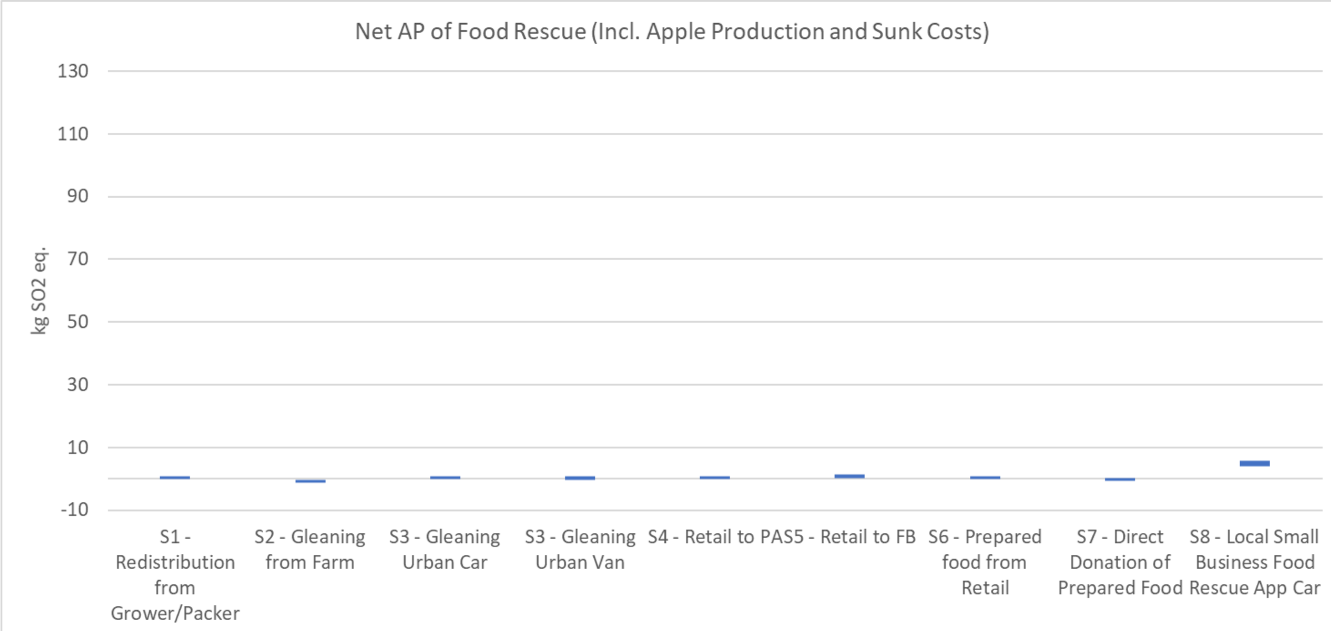

Figure 52 - Range of Net AP for All Rescue Scenarios including Upstream Production of Apples and Sunk Costs

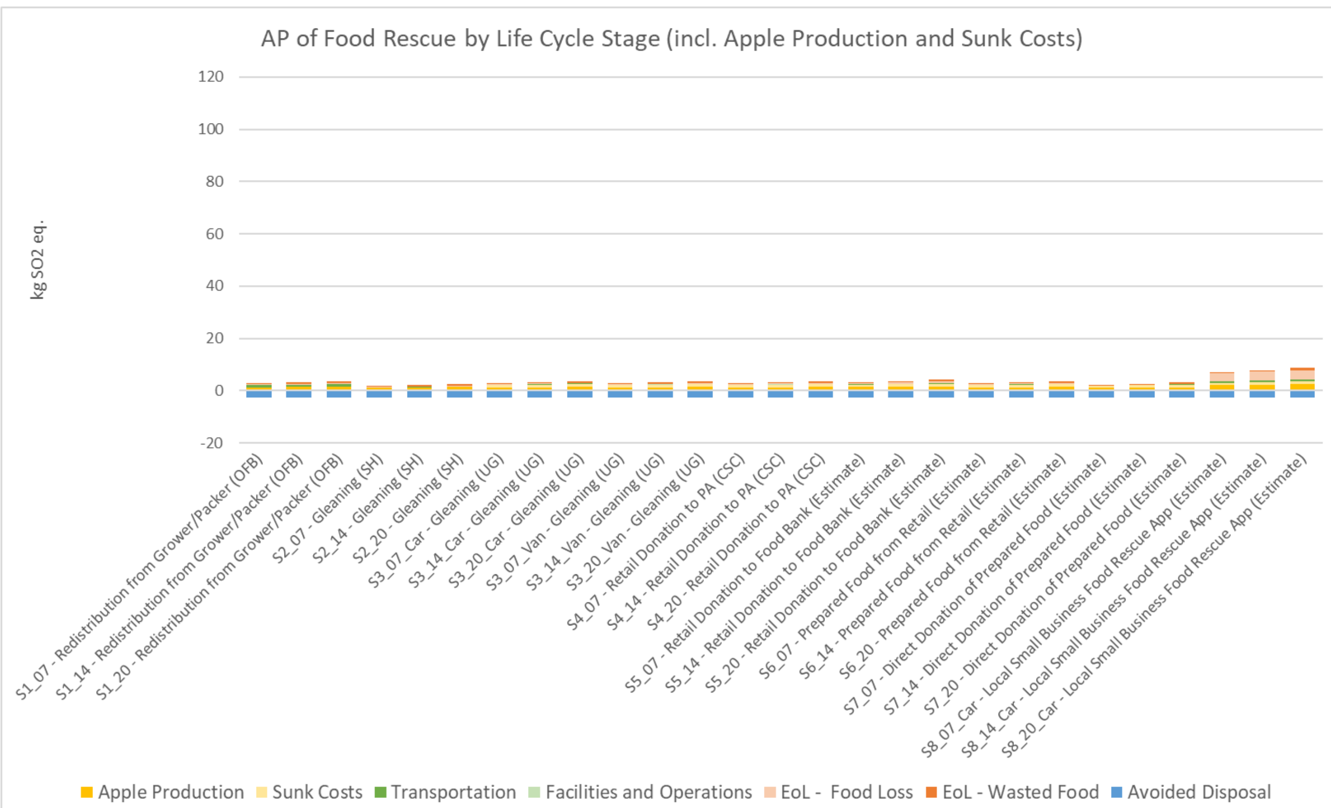

Figure 53 - AP by Life Cycle Stage for All Scenarios including Upstream Production of Apples and Sunk Costs

8.1.4 Smog Formation Potential (SFP)

The release of smog forming compounds is a function of upstream food production, and the magnitude of SFP correlates with the type of food. However, transportation mode and distance remain meaningful contributors in a few instances, as evidenced by the high releases of ozone equivalents in Scenario 1 and Scenario 8. Sunk costs also are a meaningful contributor to SFP, particularly the transportation related portion of sunk costs. There are no scenarios that result in net negative SFP when upstream food production and sunk costs are included. Additionally scenario 1 no longer stands out with the highest SFP, but scenario 8 still leads to the highest SFP across all scenarios and foods.

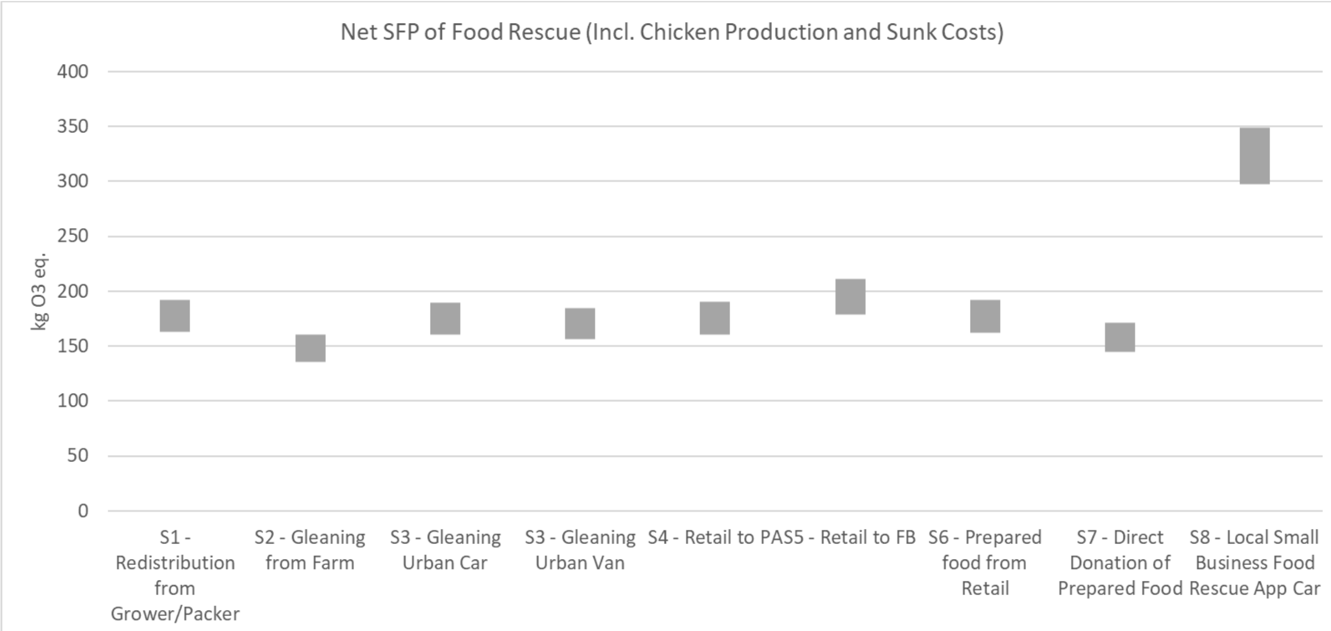

Figure 54 - Range of Net SFP for All Rescue Scenarios including Upstream Production of Chicken and Sunk Costs

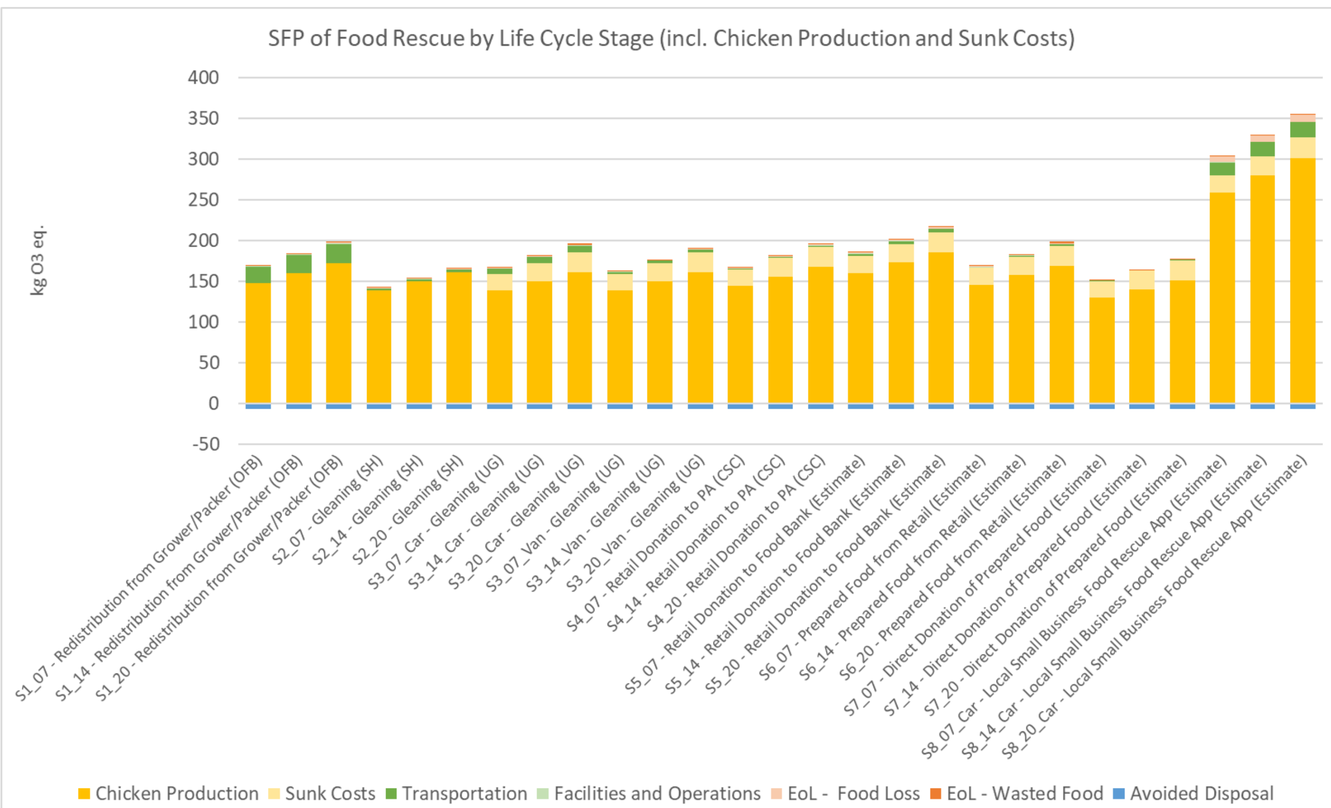

Figure 55 - SFP by Life Cycle Stage for All Scenarios including Upstream Production of Chicken and Sunk Costs

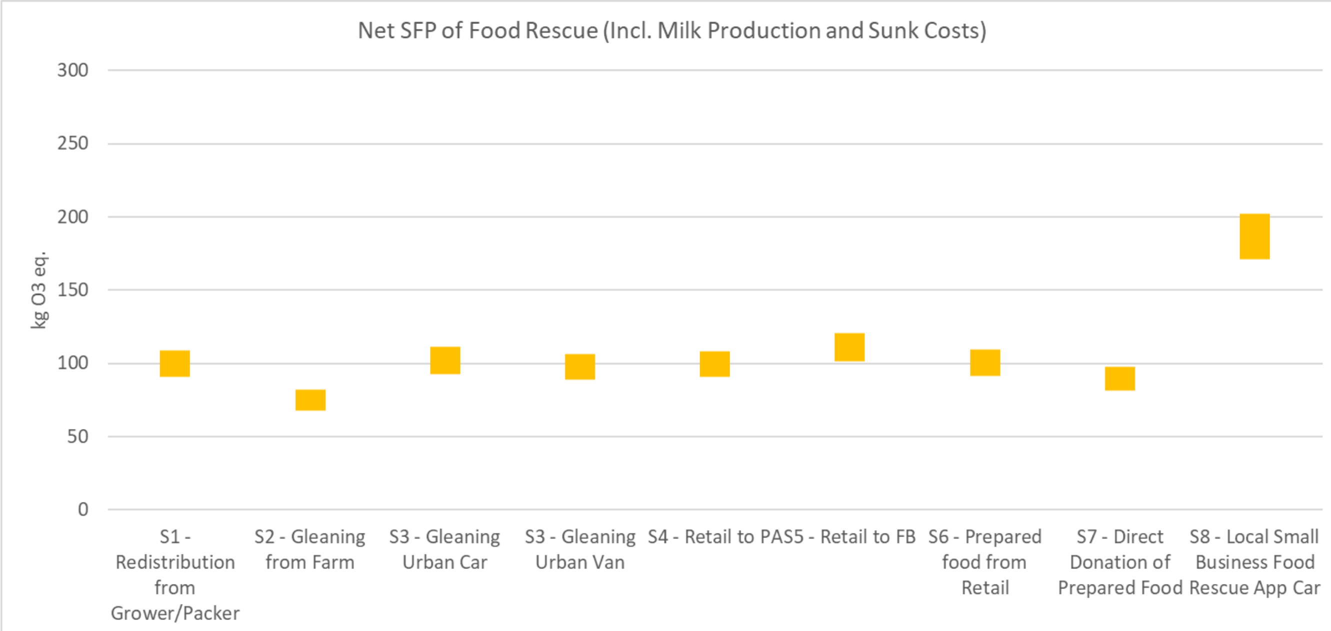

Figure 56 - Range of Net SFP for All Rescue Scenarios including Upstream Production of Milk and Sunk Costs

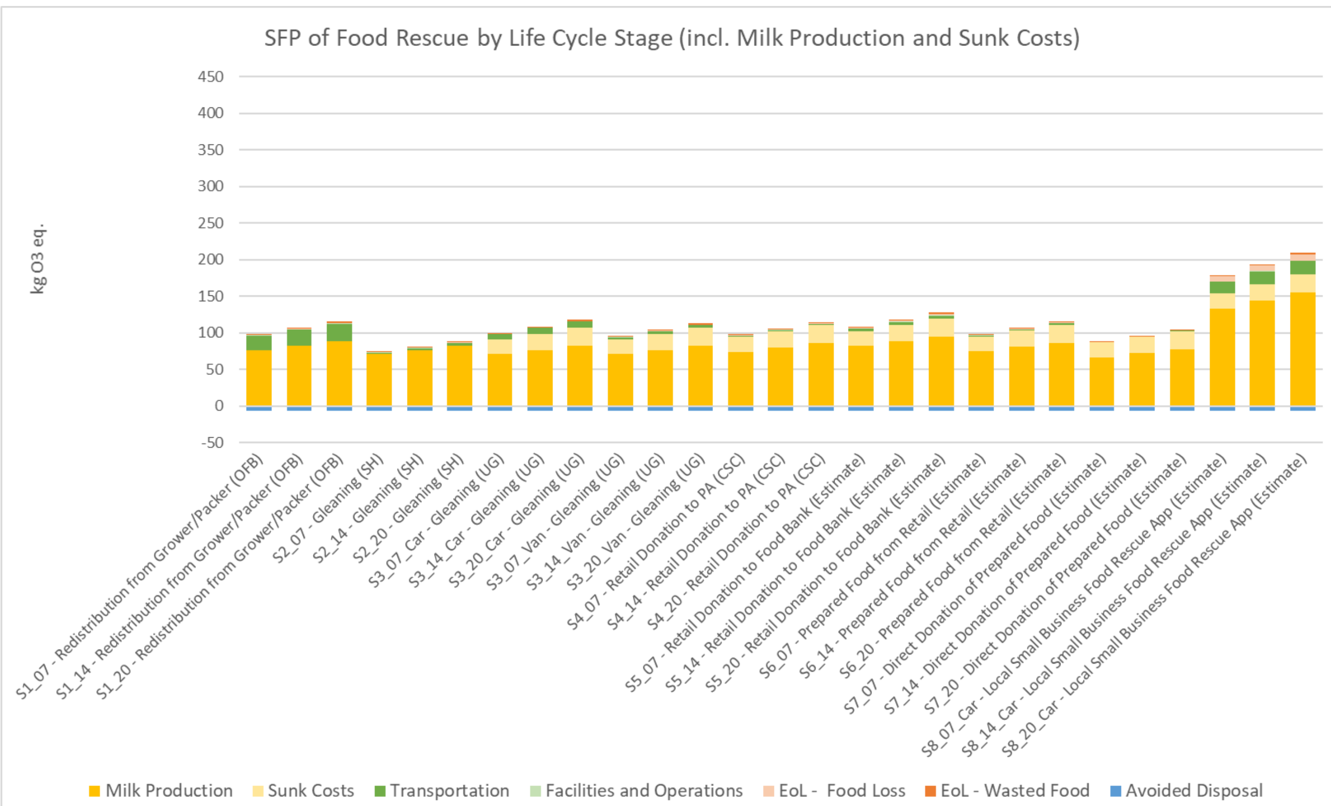

Figure 57 - SFP by Life Cycle Stage for All Scenarios including Upstream Production of Milk and Sunk Costs

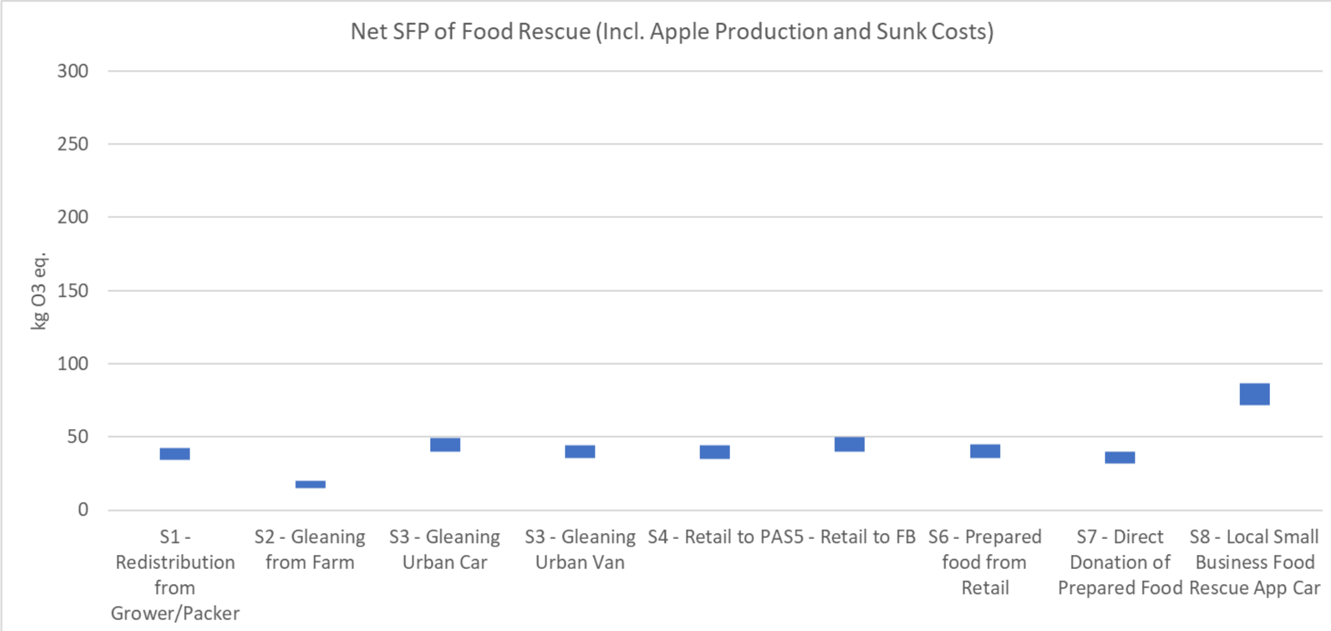

Figure 58 - Range of Net SFP for All Rescue Scenarios including Upstream Production of Apples and Sunk Costs

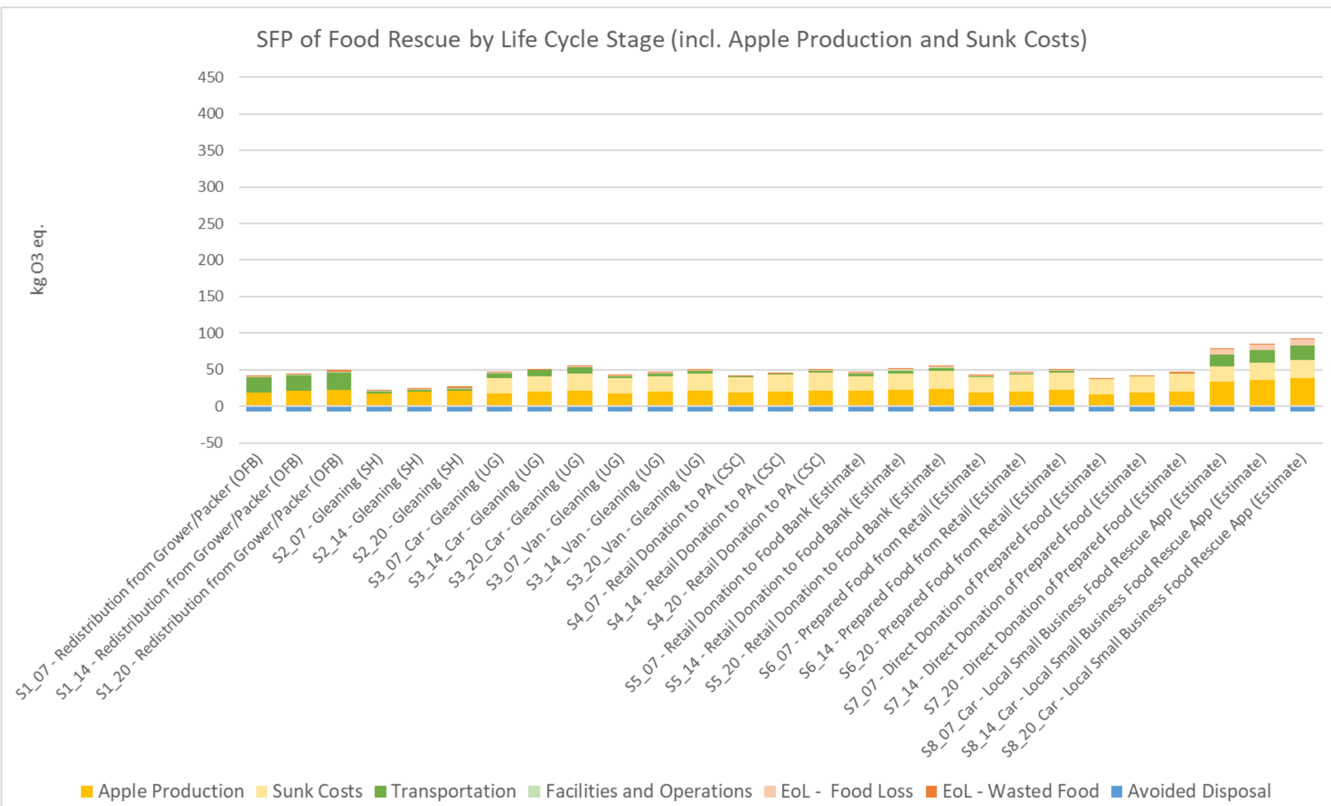

Figure 59 – SFP by Life Cycle Stage for All Scenarios including Upstream Production of Apples and Sunk Costs

8.1.5 Ozone Depletion Potential (ODP)

Ozone depletion is one of the only impact categories where transportation is not a relevant contributor to emissions. Now with the expanded system boundary of this sensitivity analysis virtually all of the releases of ozone depleting substances happen upstream. These releases are a function of food production and all the inputs required for agriculture (e.g., fuels, energy, fertilizers, pesticides, and other ancillaries). The release of ozone depleting substances are estimated to be quite small (between 10E-05 and 10E-04) in absolute terms across all scenarios, though this is three orders of magnitude larger than the results, which excluded upstream production and sunk costs.

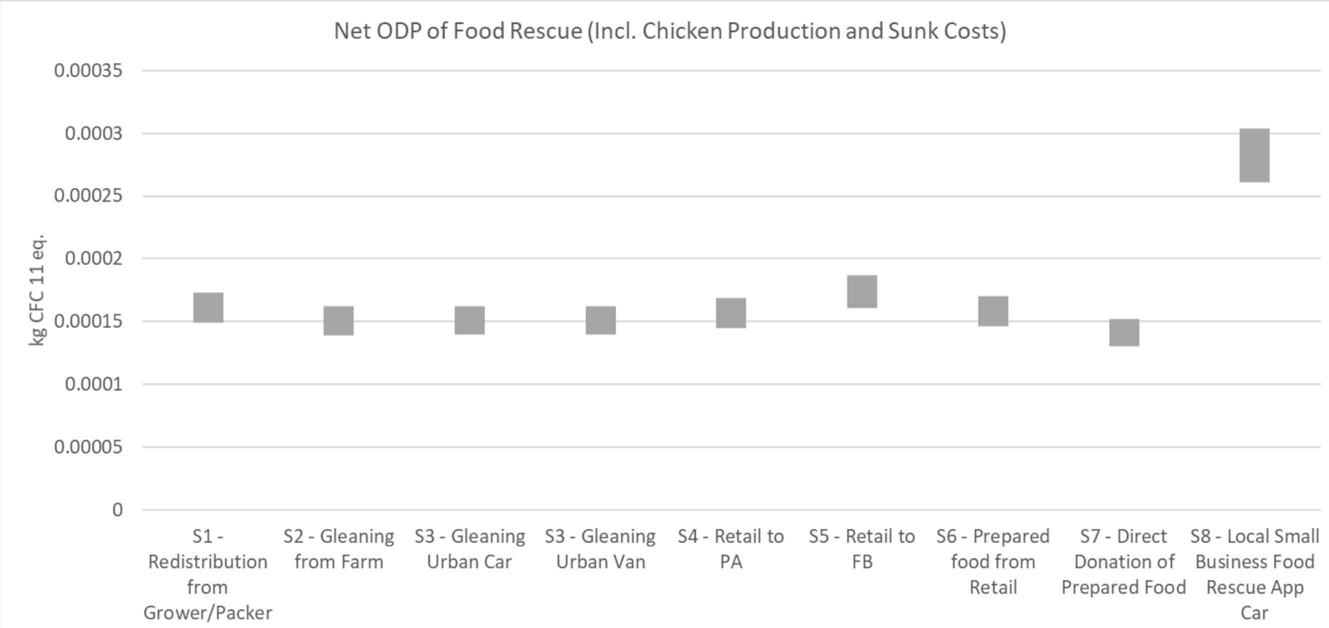

Figure 60 - Range of Net ODP for All Rescue Scenarios including Upstream Production of Chicken and Sunk Costs

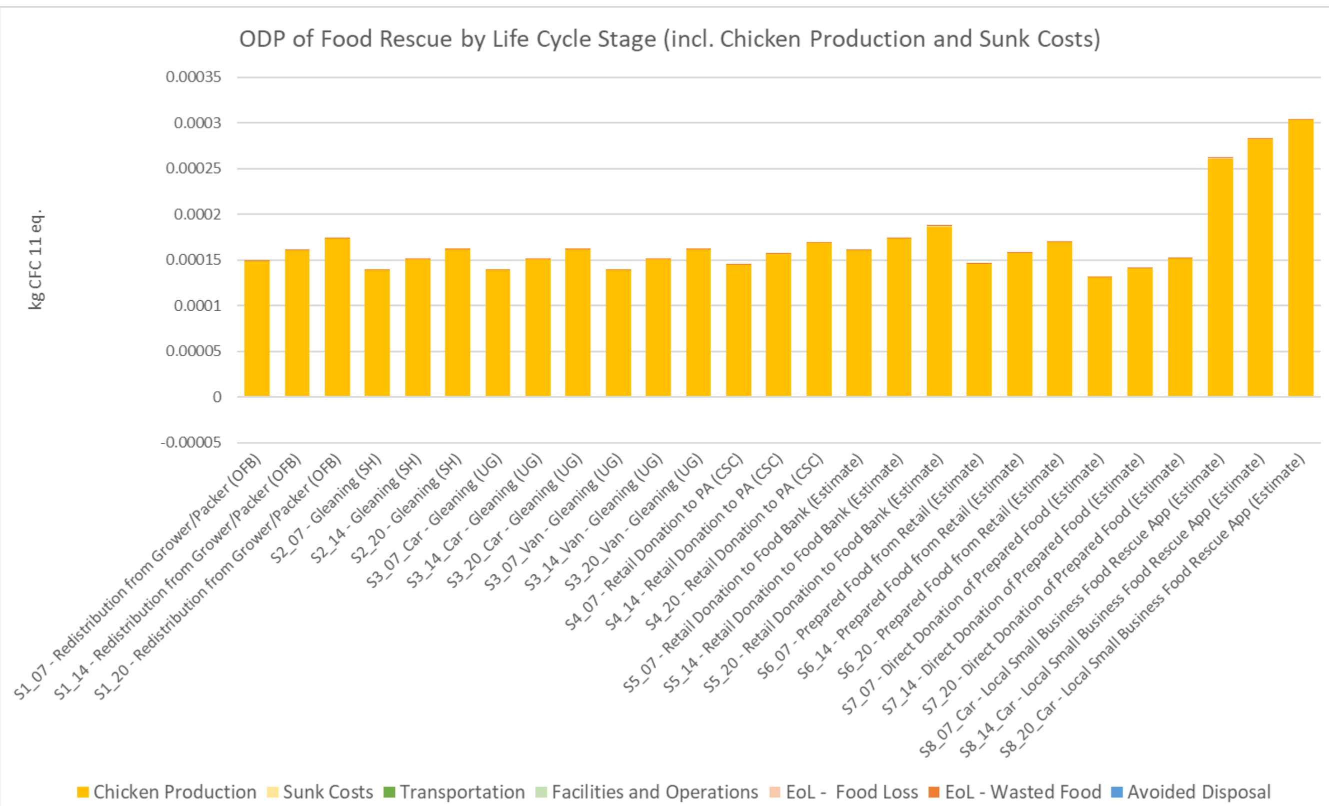

Figure 61 - ODP by Life Cycle Stage for All Scenarios including Upstream Production of Chicken and Sunk Costs

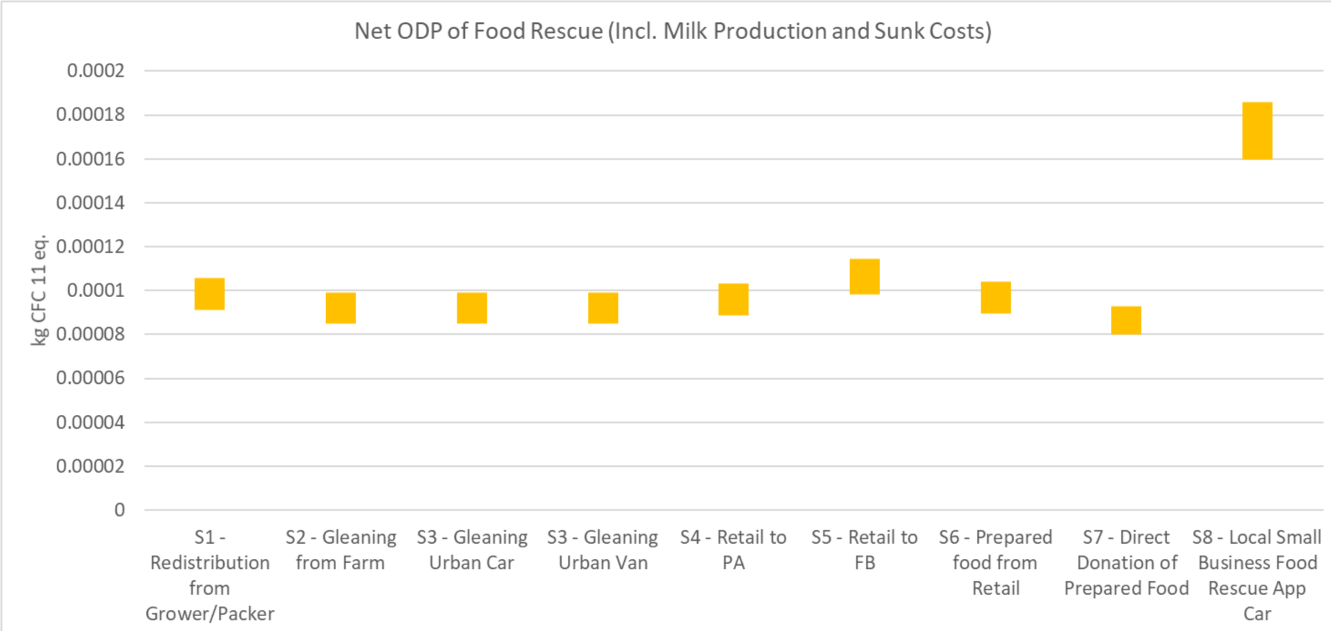

Figure 62 - Range of Net ODP for All Rescue Scenarios including Upstream Production of Milk and Sunk Costs

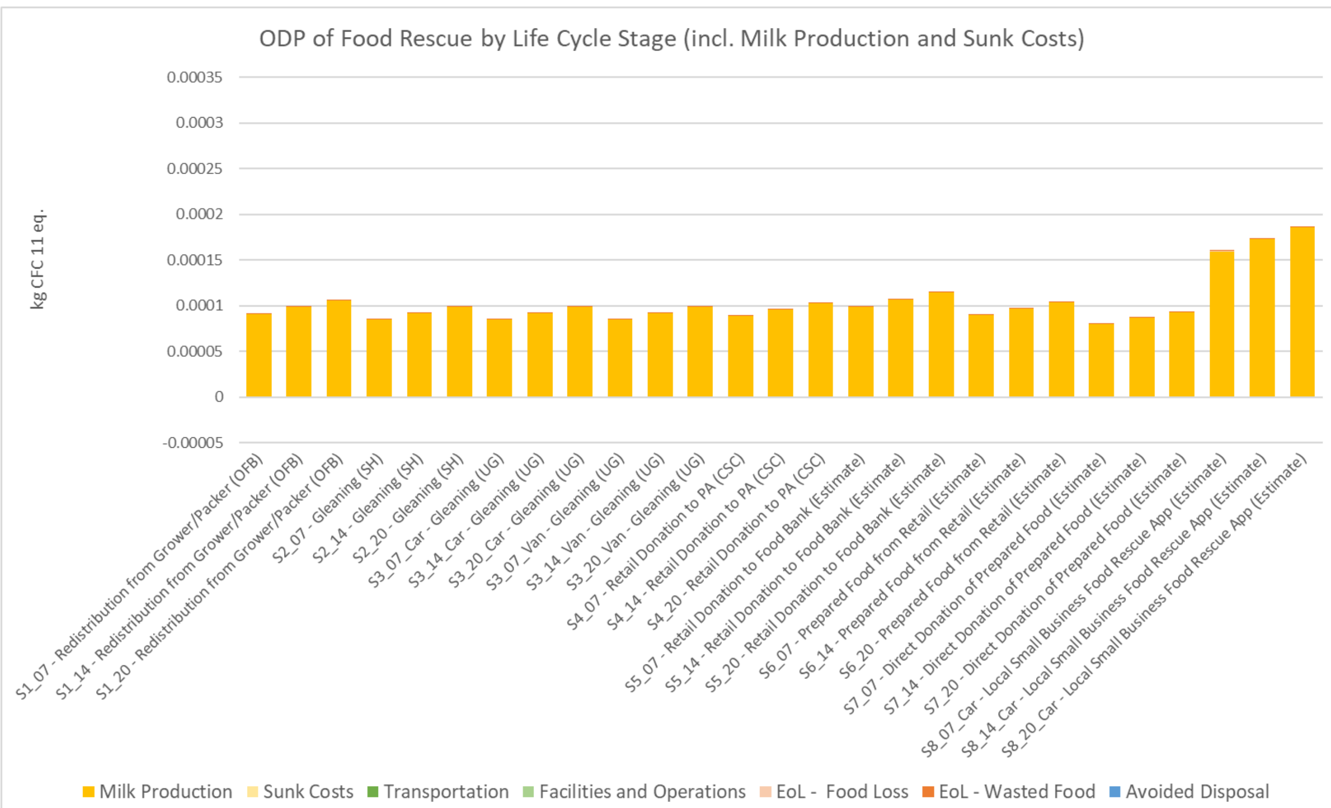

Figure 63 - ODP by Life Cycle Stage for All Scenarios including Upstream Production of Milk and Sunk Costs

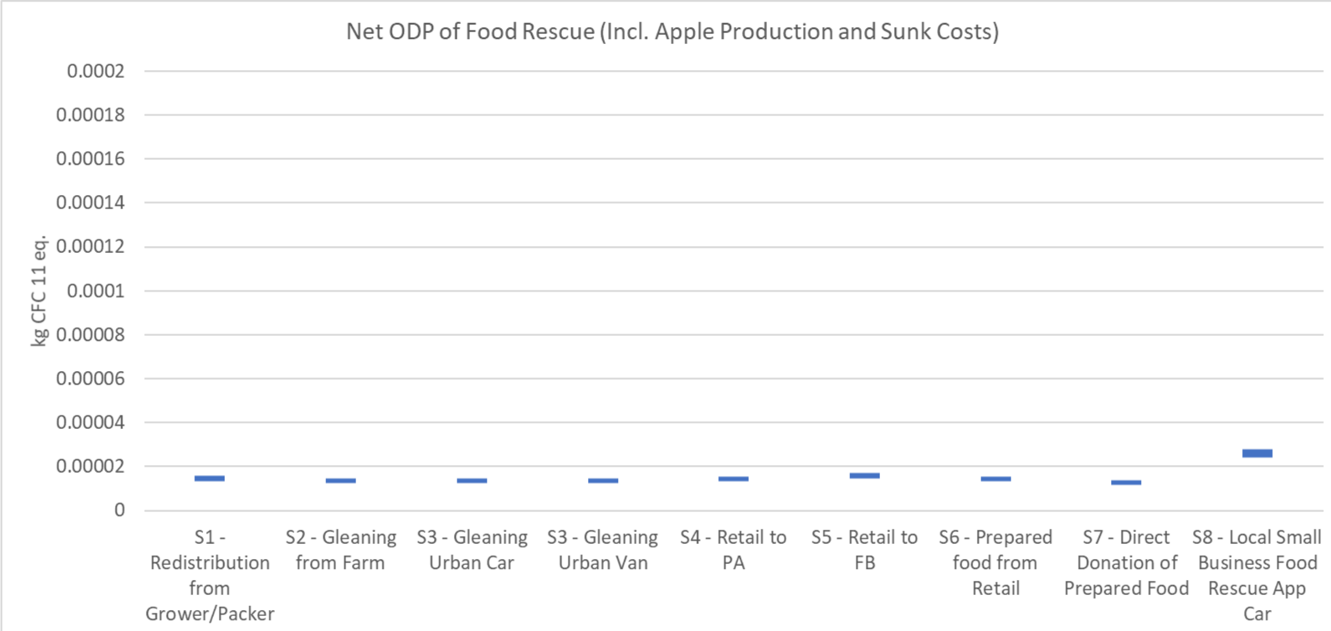

Figure 64 - Range of Net ODP for All Rescue Scenarios including Upstream Production of Apples and Sunk Costs

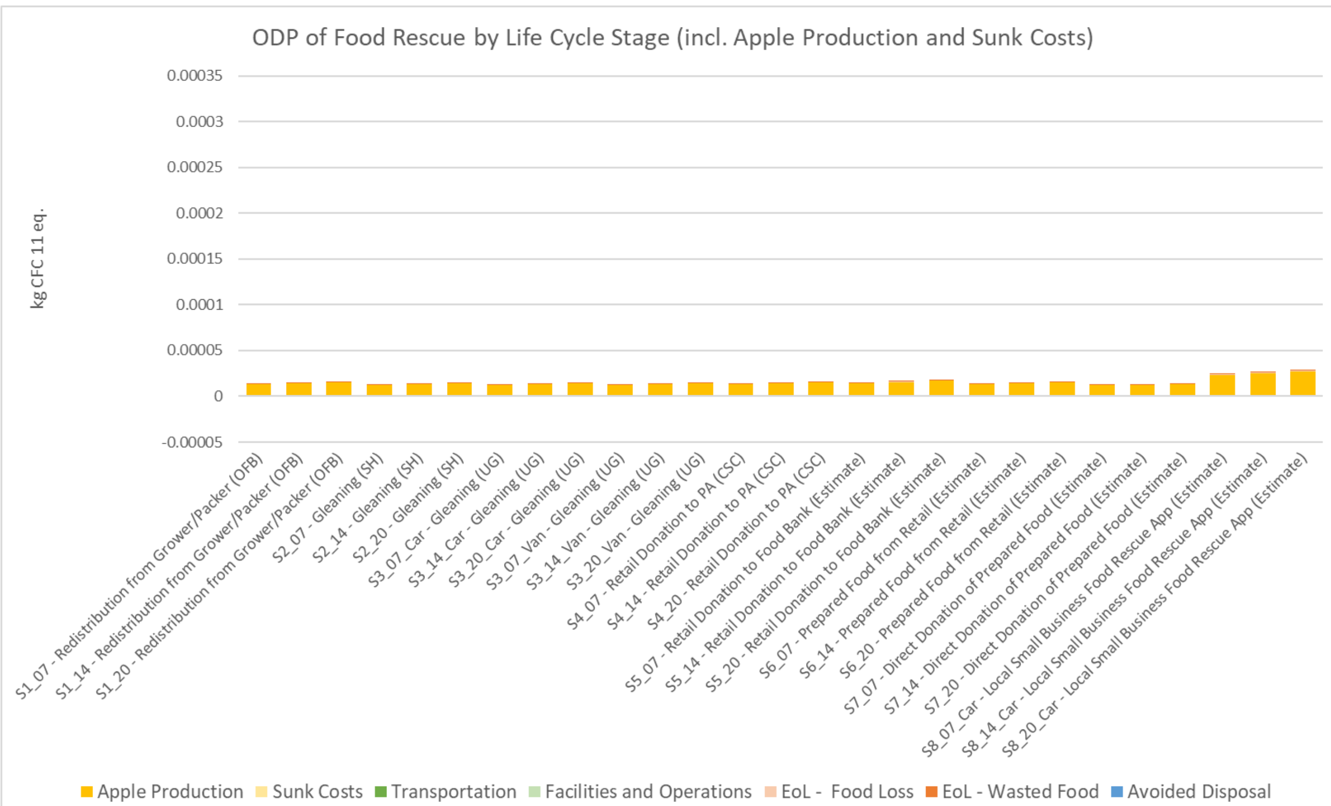

Figure 65 – ODP by Life Cycle Stage for All Scenarios including Upstream Production of Apples and Sunk Costs

8.1.6 Human Health Particulate Air (PM2.5)

The release of particulates to air is due almost exclusively to upstream food production. Transportation, formerly an important contributor to the results, is now virtually irrelevant to the life cycle impacts of PM2.5. As in all cases above, the type of upstream food production correlates with the overall magnitude of impact, with chicken leading to the highest and apples the lowest potential to form PM2.5.

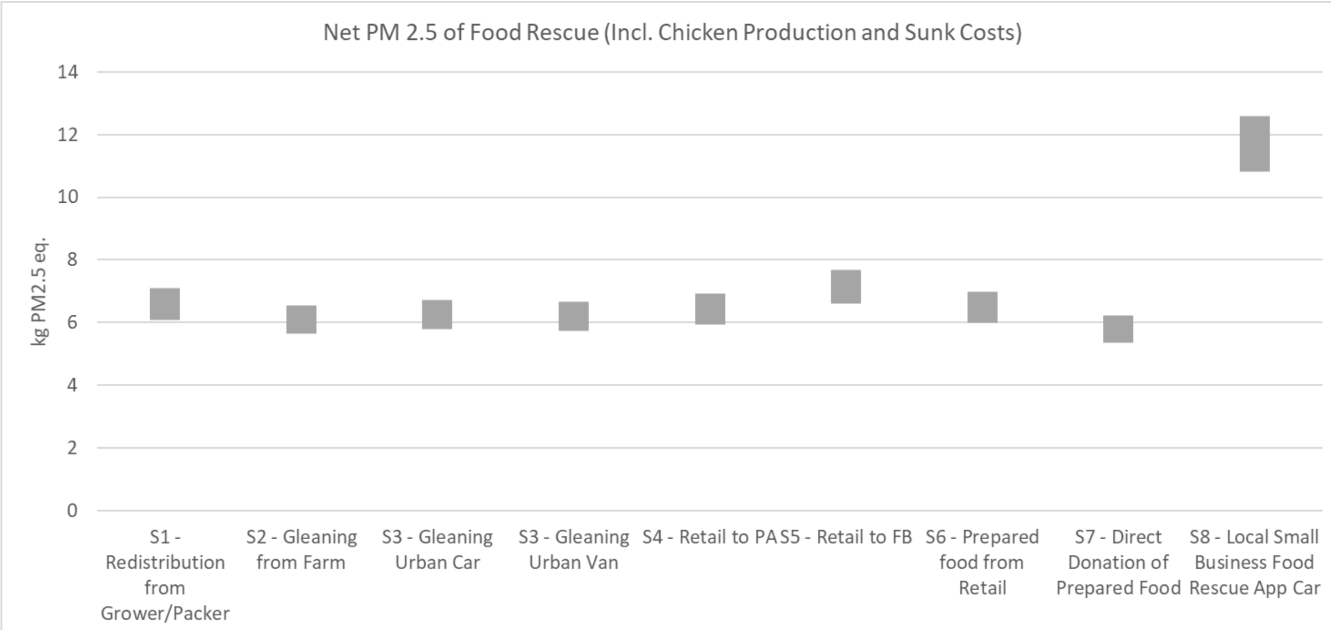

Figure 66 - Range of Net PM 2.5 for All Rescue Scenarios including Upstream Production of Chicken and Sunk Costs

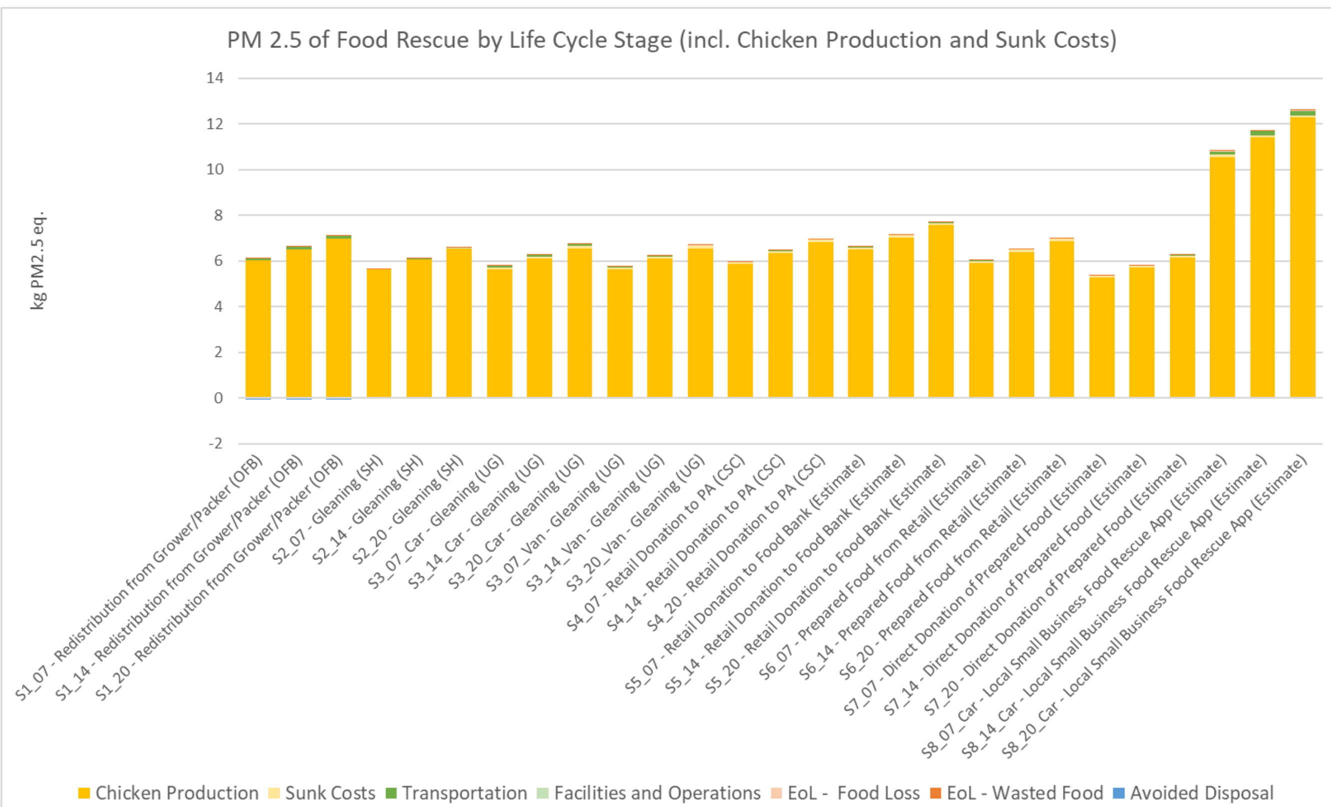

Figure 67 – PM 2.5 by Life Cycle Stage for All Scenarios including Upstream Production of Chicken and Sunk Costs

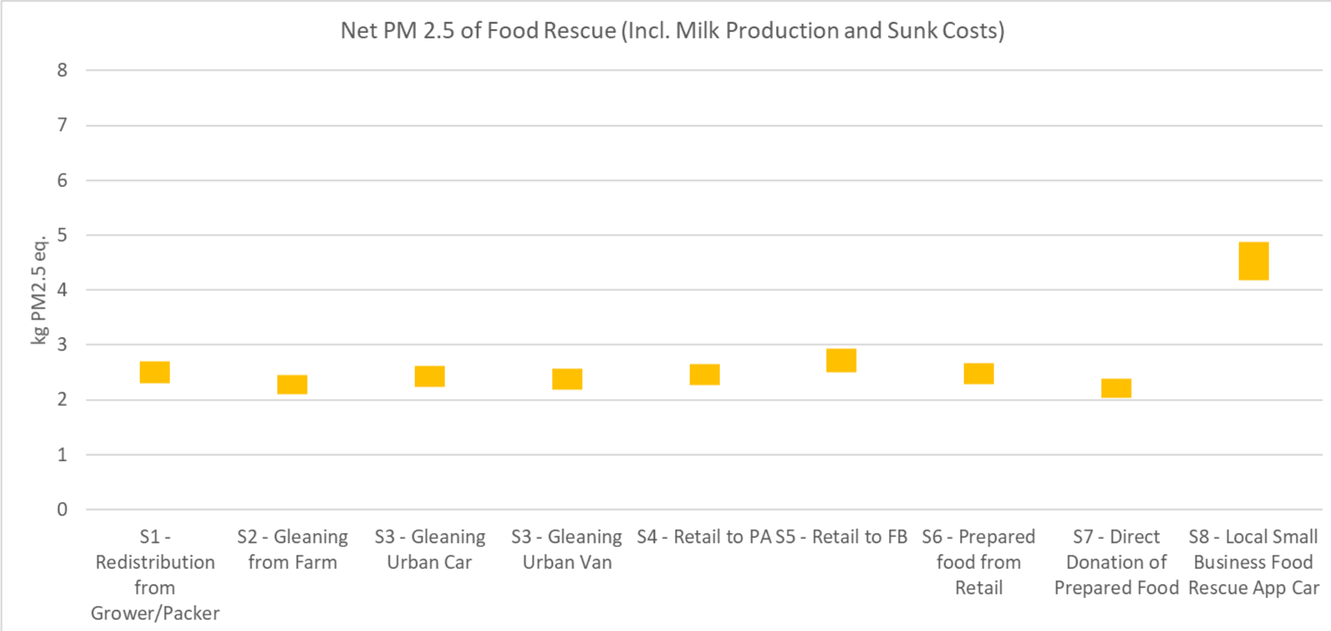

Figure 68 - Range of Net PM 2.5 for All Rescue Scenarios including Upstream Production of Milk and Sunk Costs

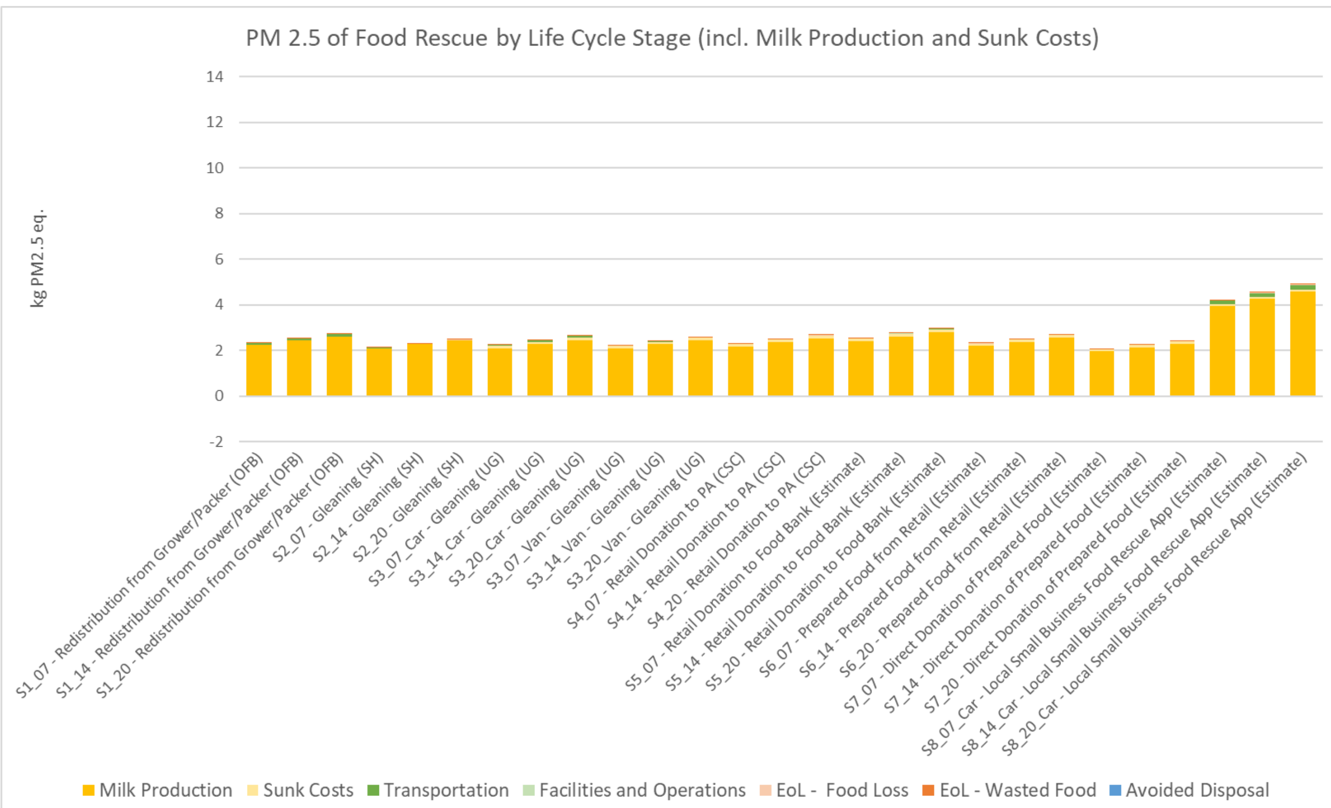

Figure 69 – PM 2.5 by Life Cycle Stage for All Scenarios including Upstream Production of Milk and Sunk Costs

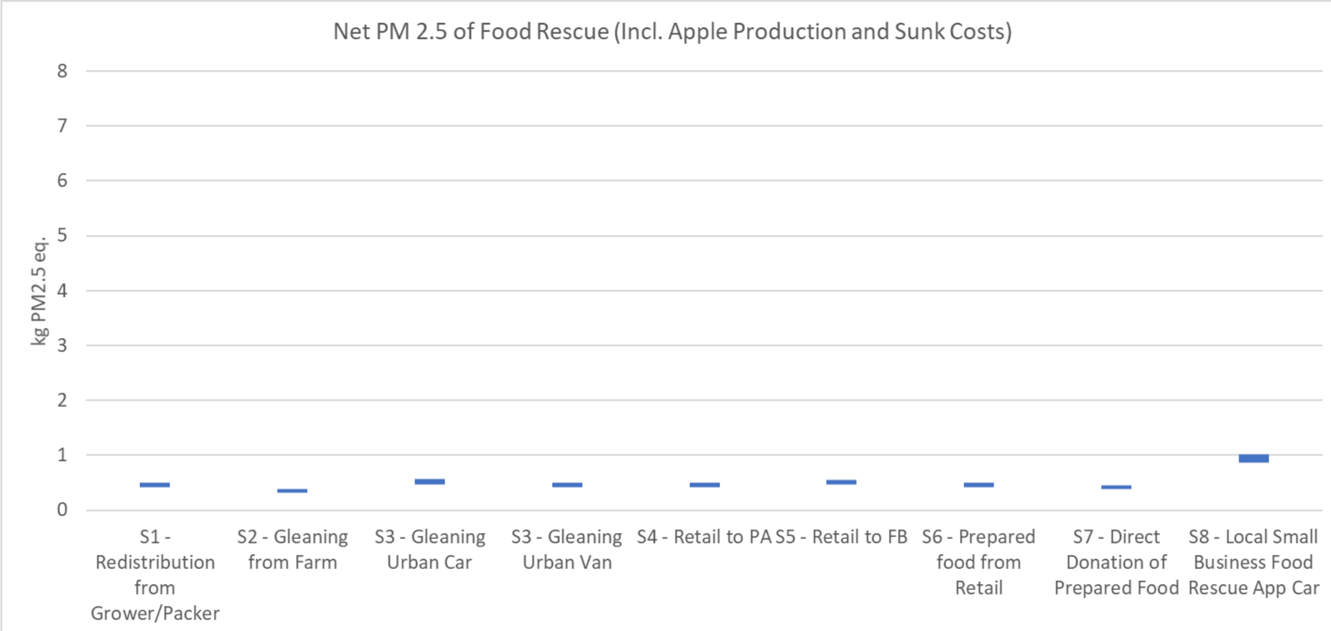

Figure 70 - Range of Net PM 2.5 for All Rescue Scenarios including Upstream Production of Apples and Sunk Costs

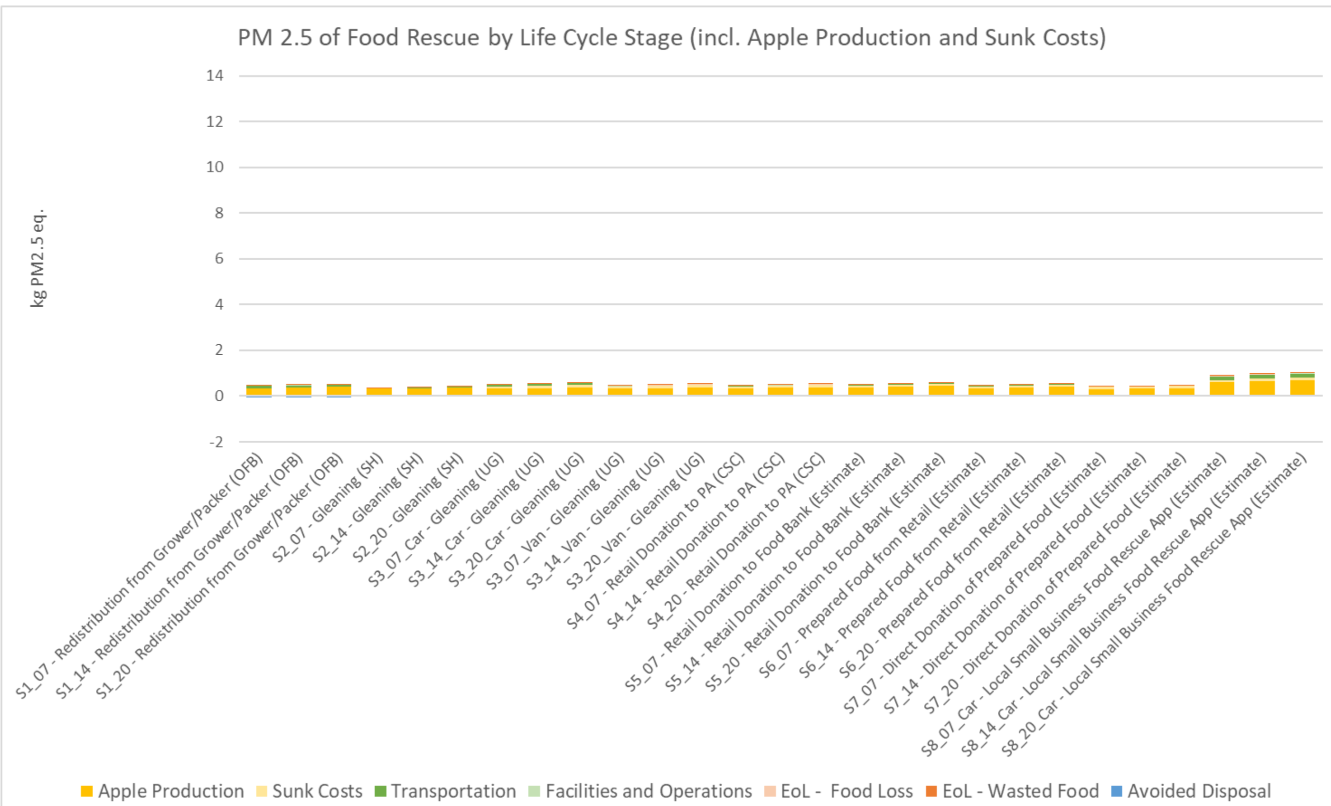

Figure 71 – PM 2.5 by Life Cycle Stage for All Scenarios including Upstream Production of Apples and Sunk Costs

8.1.7 Primary Energy Demand (PERNRT)

The results show that energy demand is primarily a function of upstream food production and secondarily due to transportation and the efficiency of a given transport mode in rescuing food. The type of food produced is the key driver in the overall PERNRT.

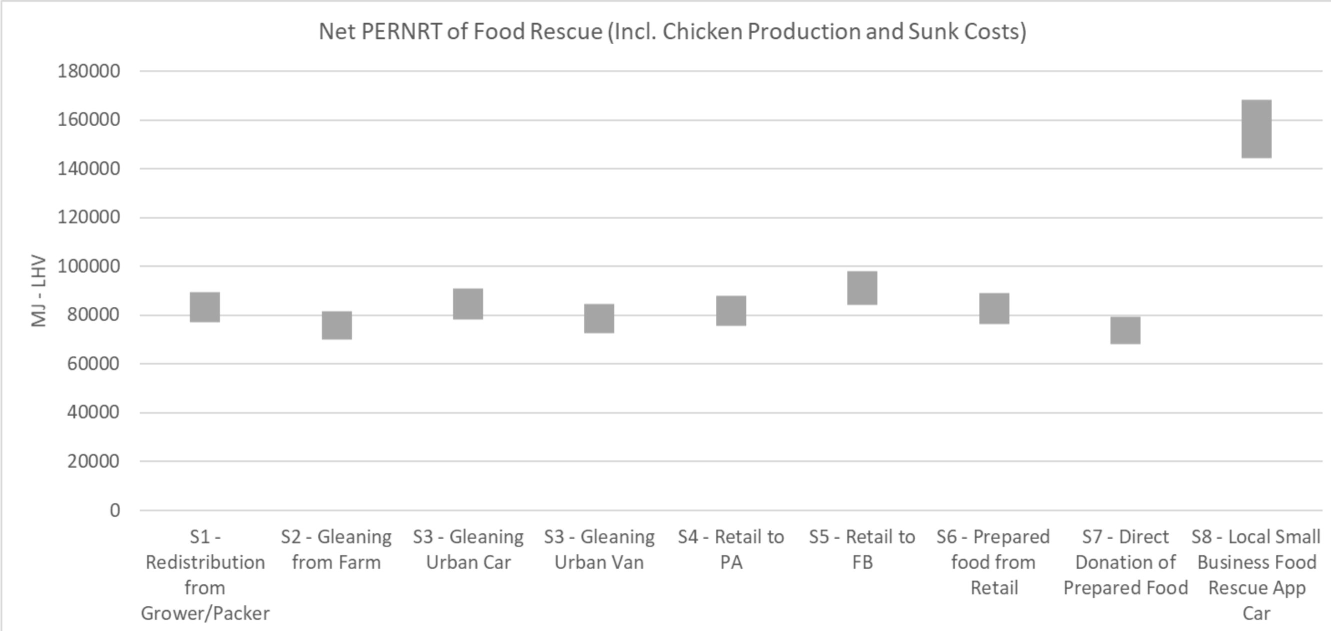

Figure 72 - Range of Net PERNRT for All Rescue Scenarios including Upstream Production of Chicken and Sunk Costs

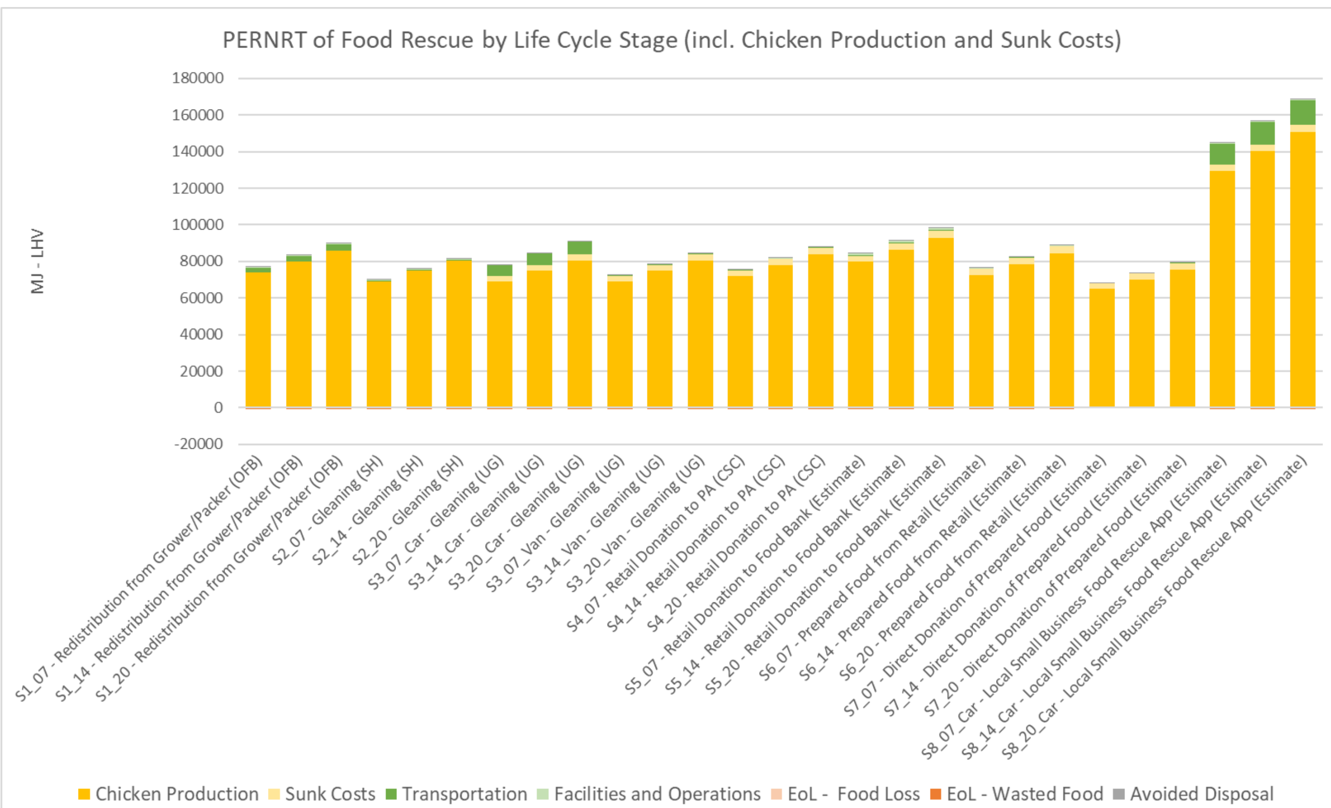

Figure 73 – PERNRT by Life Cycle Stage for All Scenarios including Upstream Production of Chicken and Sunk Costs

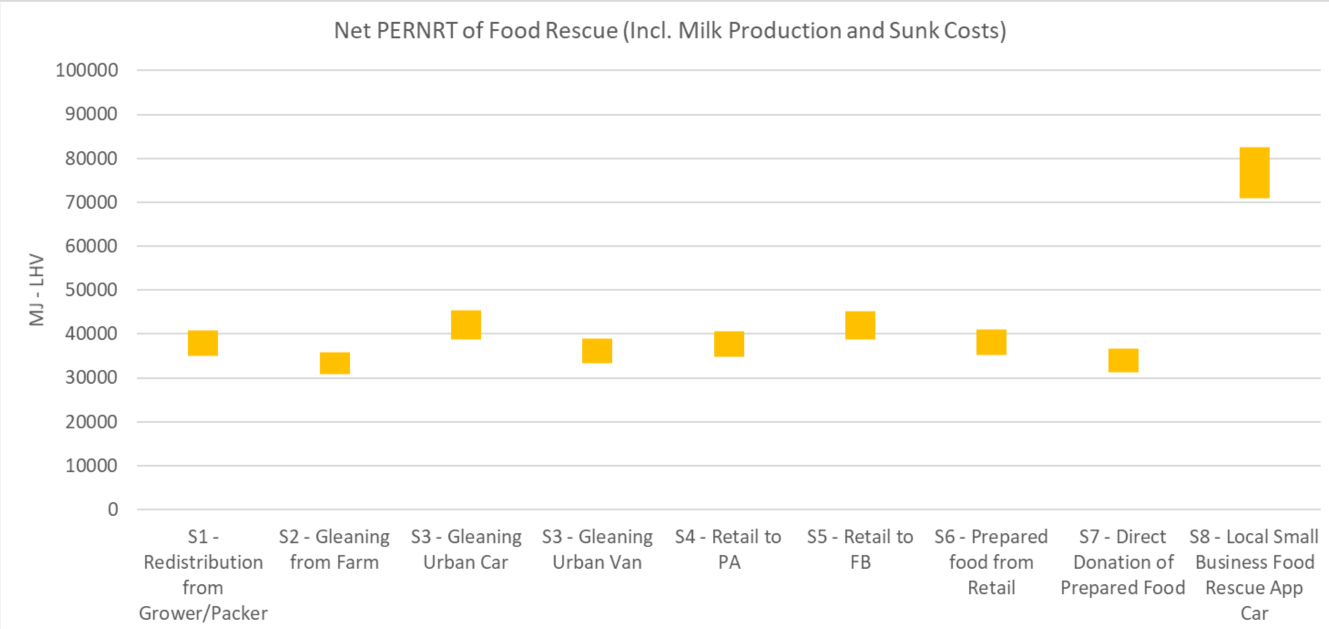

Figure 74 - Range of Net PERNRT for All Rescue Scenarios including Upstream Production of Milk and Sunk Costs

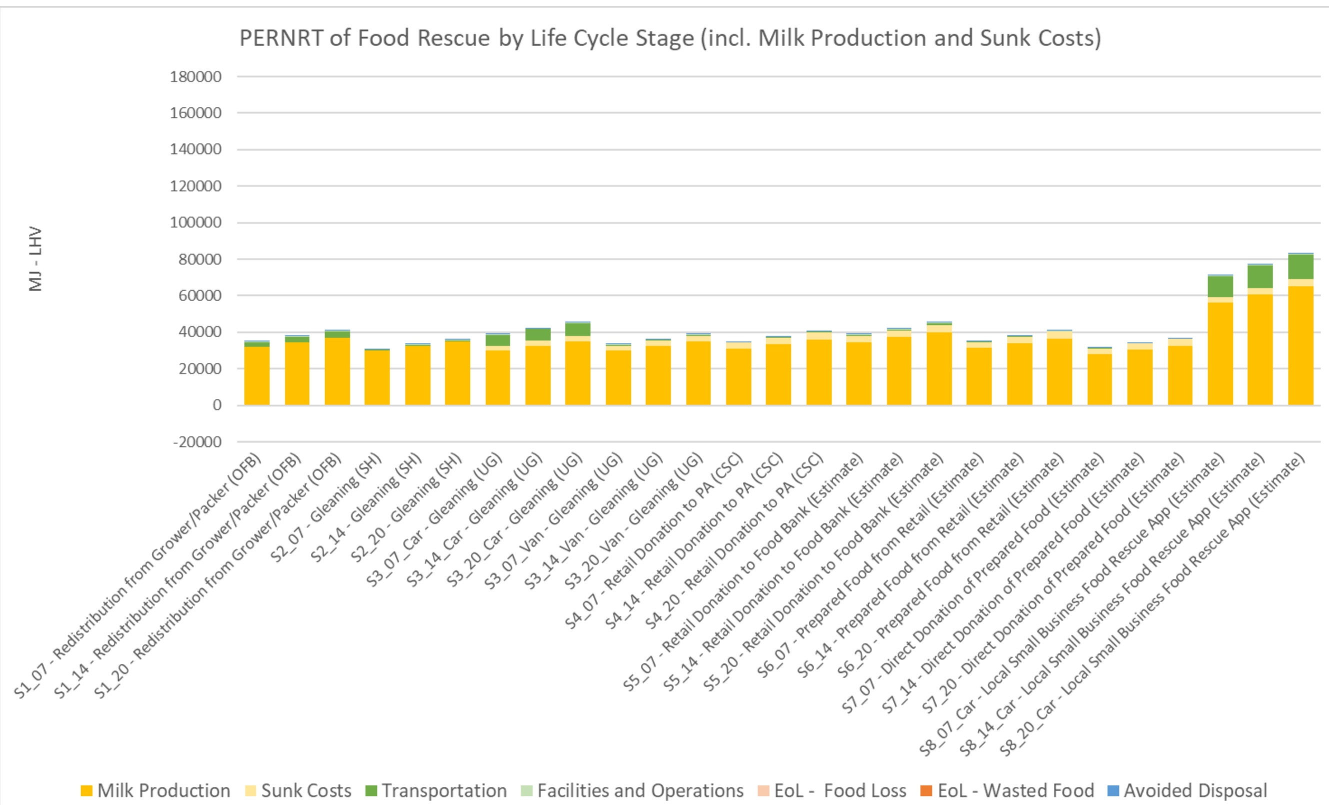

Figure 75 – PERNRT by Life Cycle Stage for All Scenarios including Upstream Production of Milk and Sunk Costs

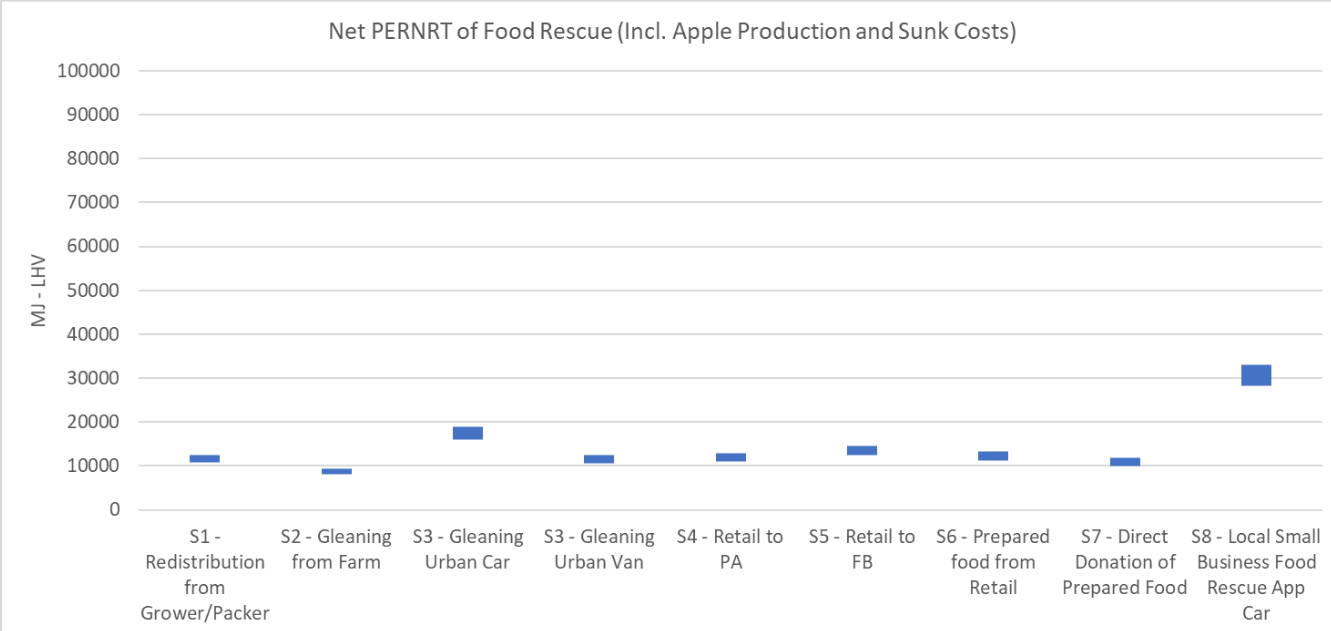

Figure 76 - Range of Net PERNRT for All Rescue Scenarios including Upstream Production of Apples and Sunk Costs

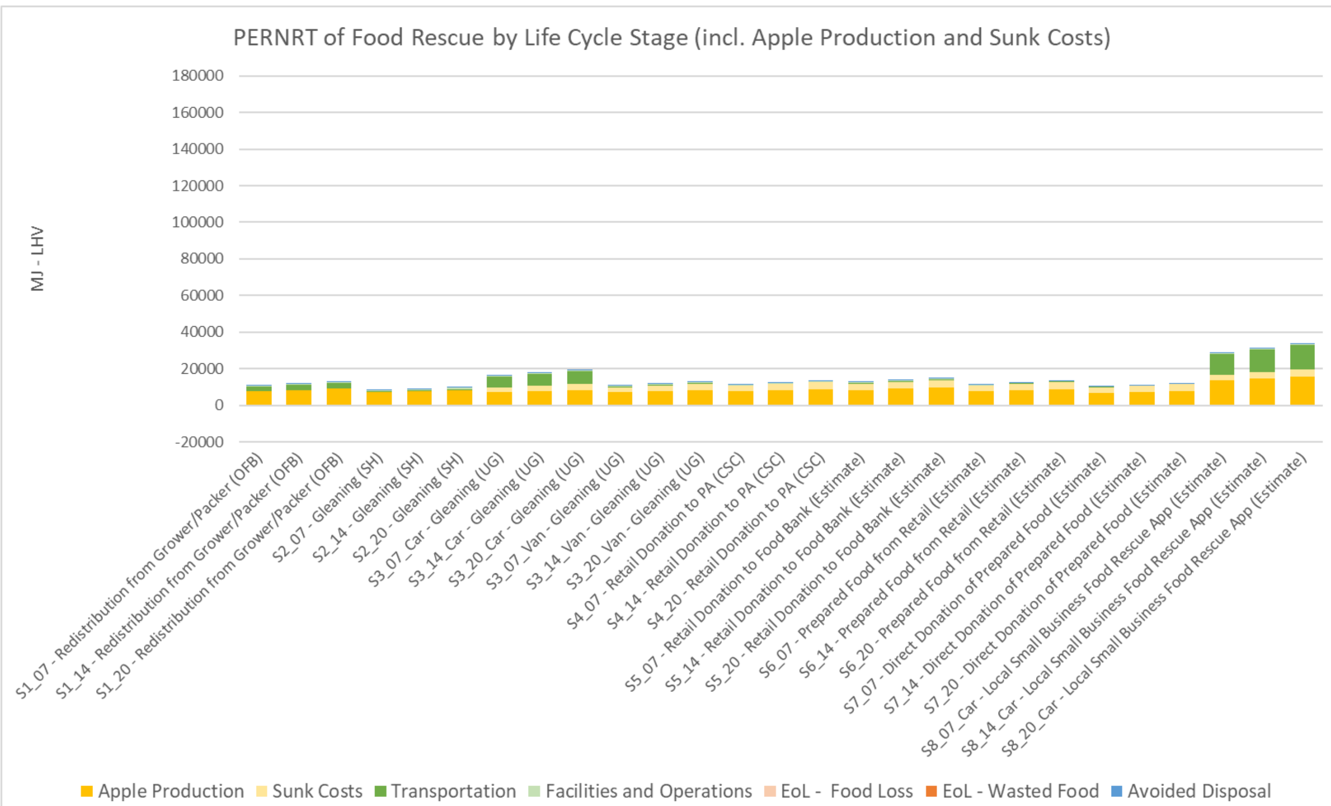

Figure 77 – PERNRT by Life Cycle Stage for All Scenarios including Upstream Production of Apples and Sunk Costs

8.1.8 Blue Water Consumption

Results for the consumption of blue water follow a similar trend as other impact categories and indicators, in that the consumption values are highest based on the type of upstream food production. All other contributions to the life cycle are *de minimis* in terms of overall blue water consumption, which speaks to the highly water-intensive nature of agricultural production of food.

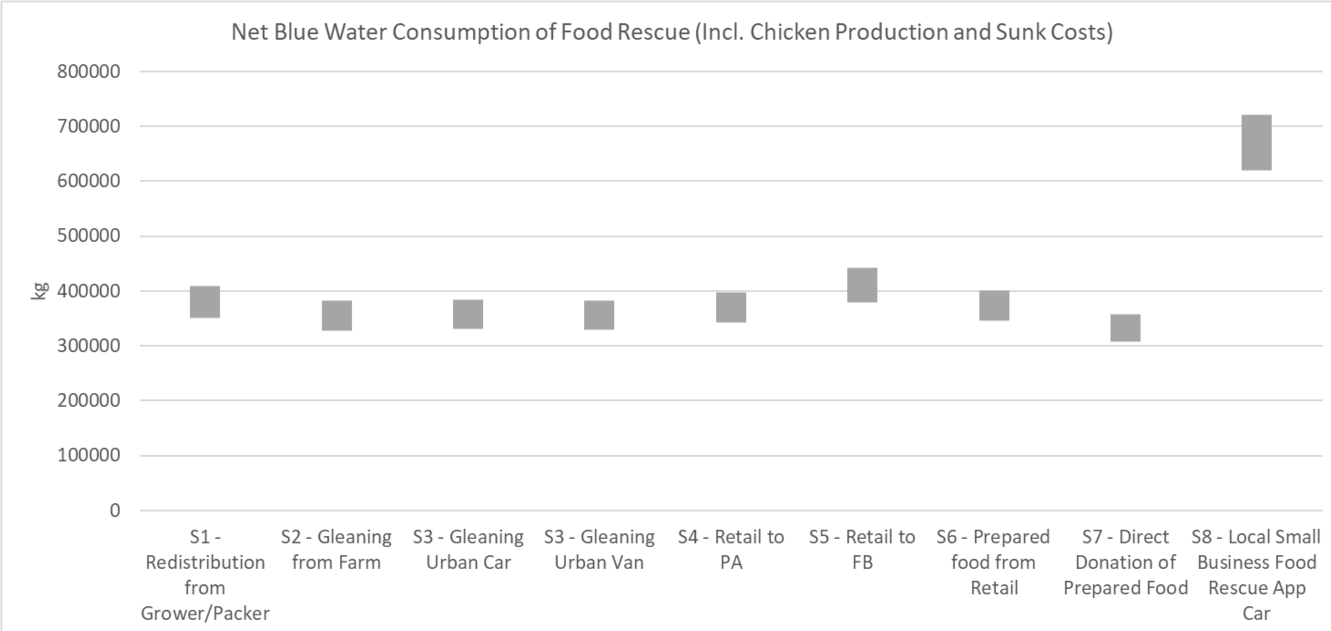

Figure 78 - Range of Net Blue Water Consumption for All Rescue Scenarios including Upstream Production of Chicken and Sunk Costs

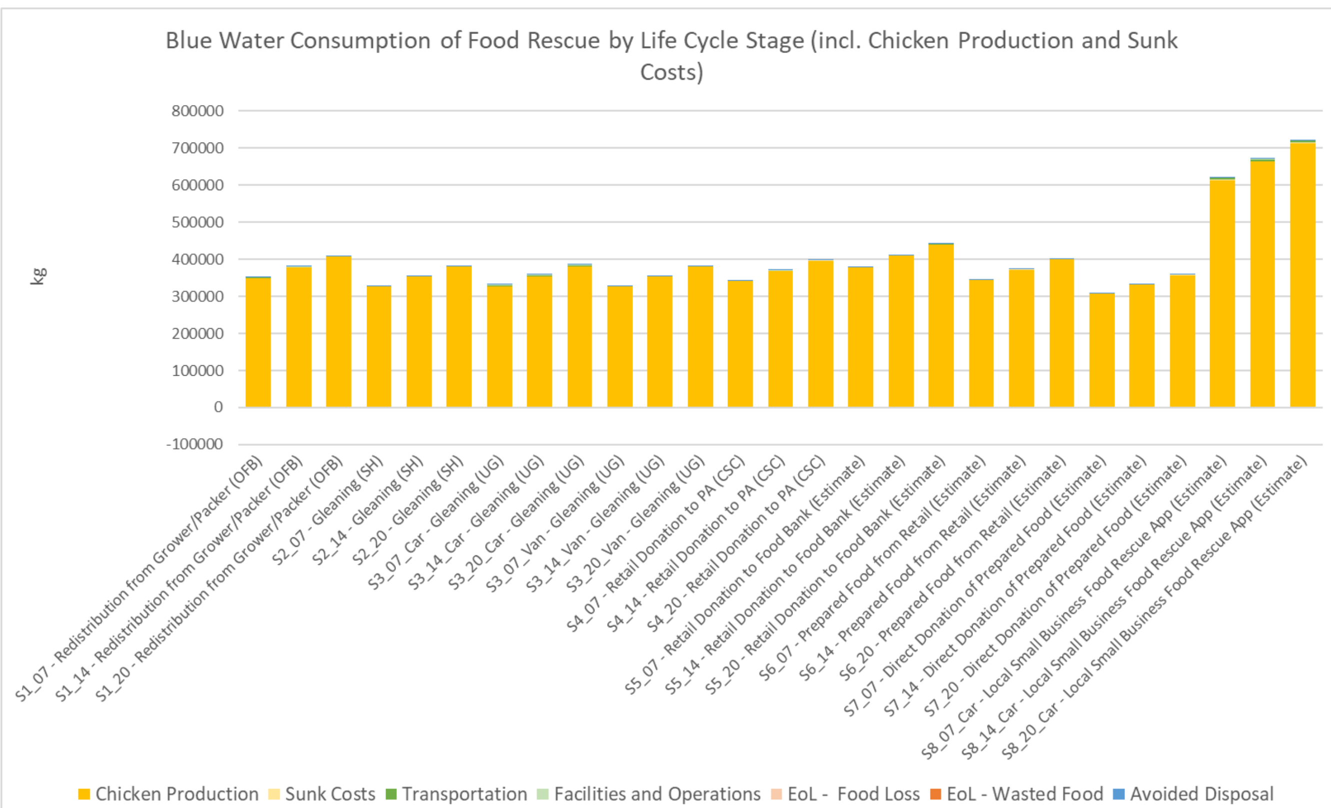

Figure 79 – Blue Water Consumption by Life Cycle Stage for All Scenarios including Upstream Production of Chicken and Sunk Costs

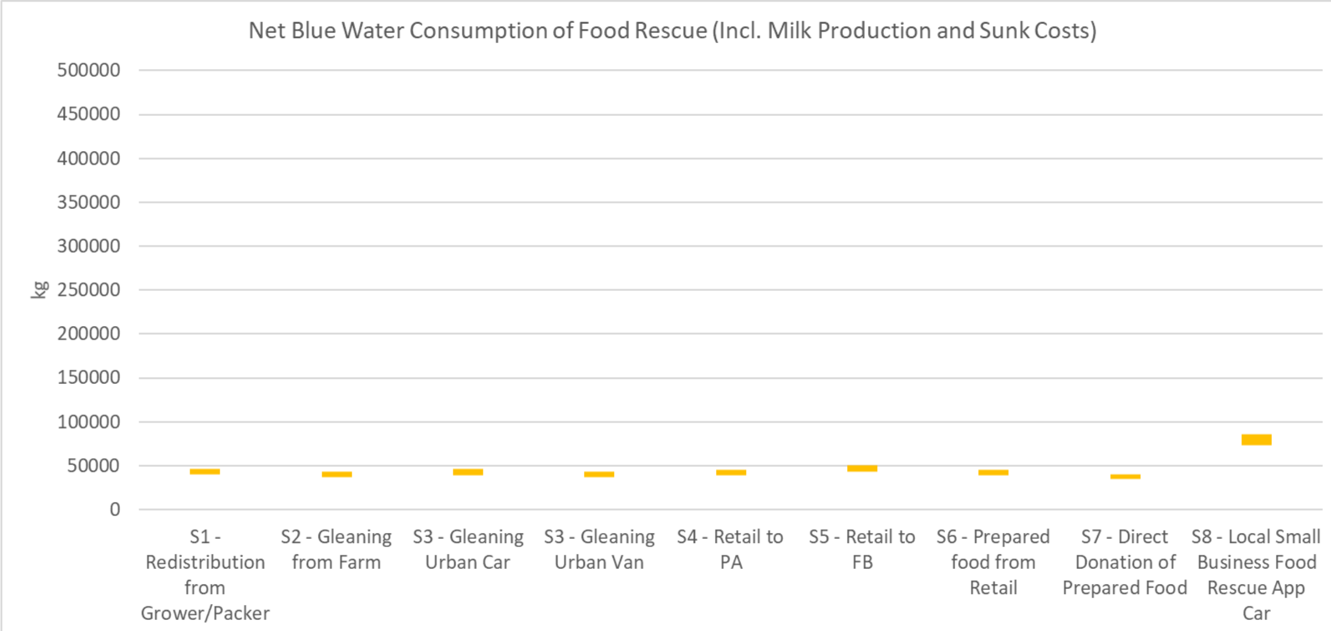

Figure 80 - Range of Net Blue Water Consumption for All Rescue Scenarios including Upstream Production of Milk and Sunk Costs

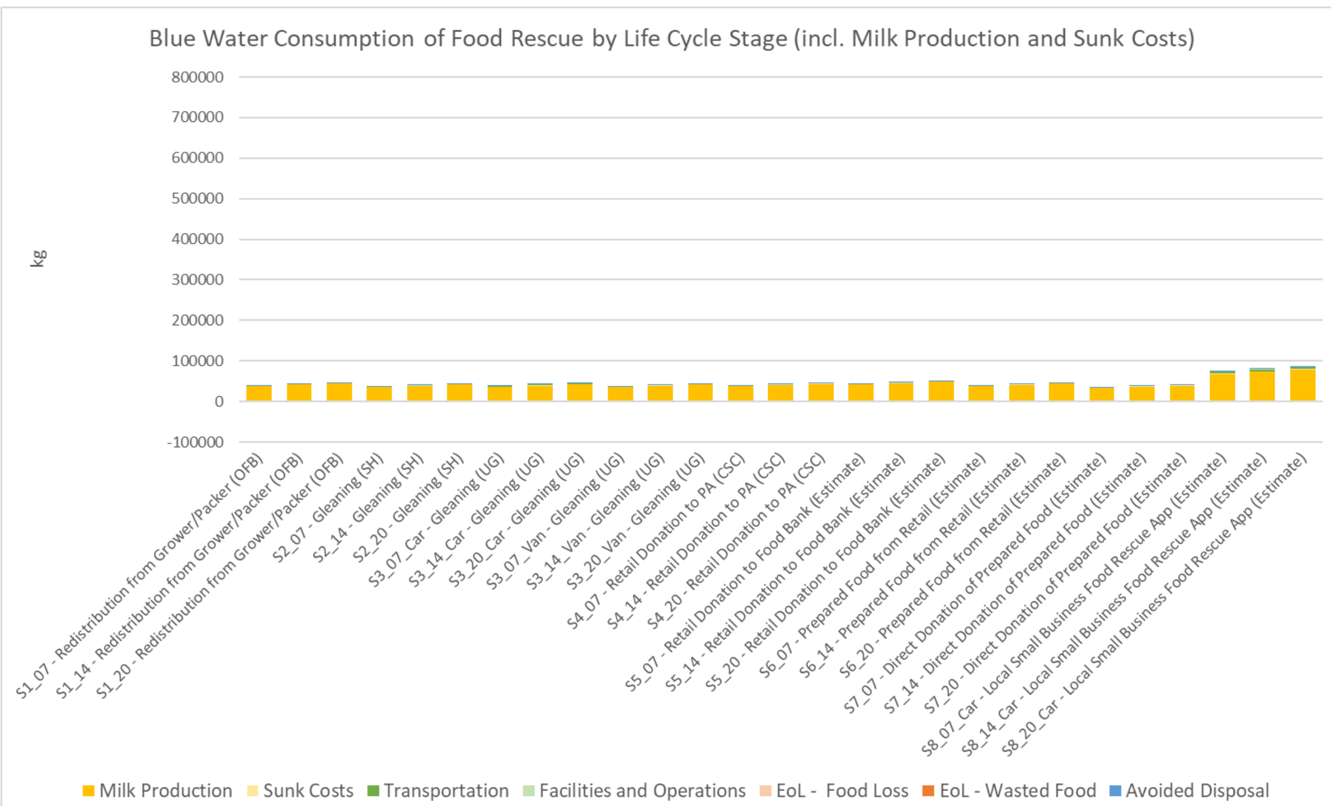

Figure 81 – Blue Water Consumption by Life Cycle Stage for All Scenarios including Upstream Production of Milk and Sunk Costs

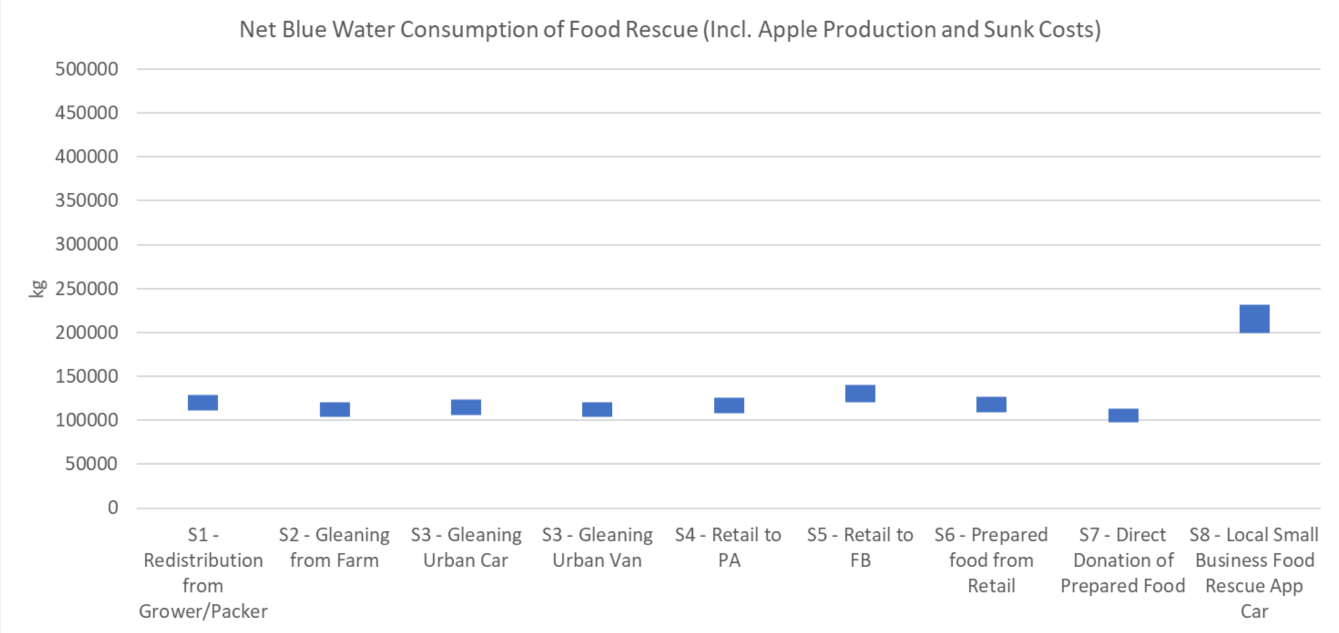

Figure 82 - Range of Net Blue Water Consumption for All Rescue Scenarios including Upstream Production of Apples and Sunk Costs

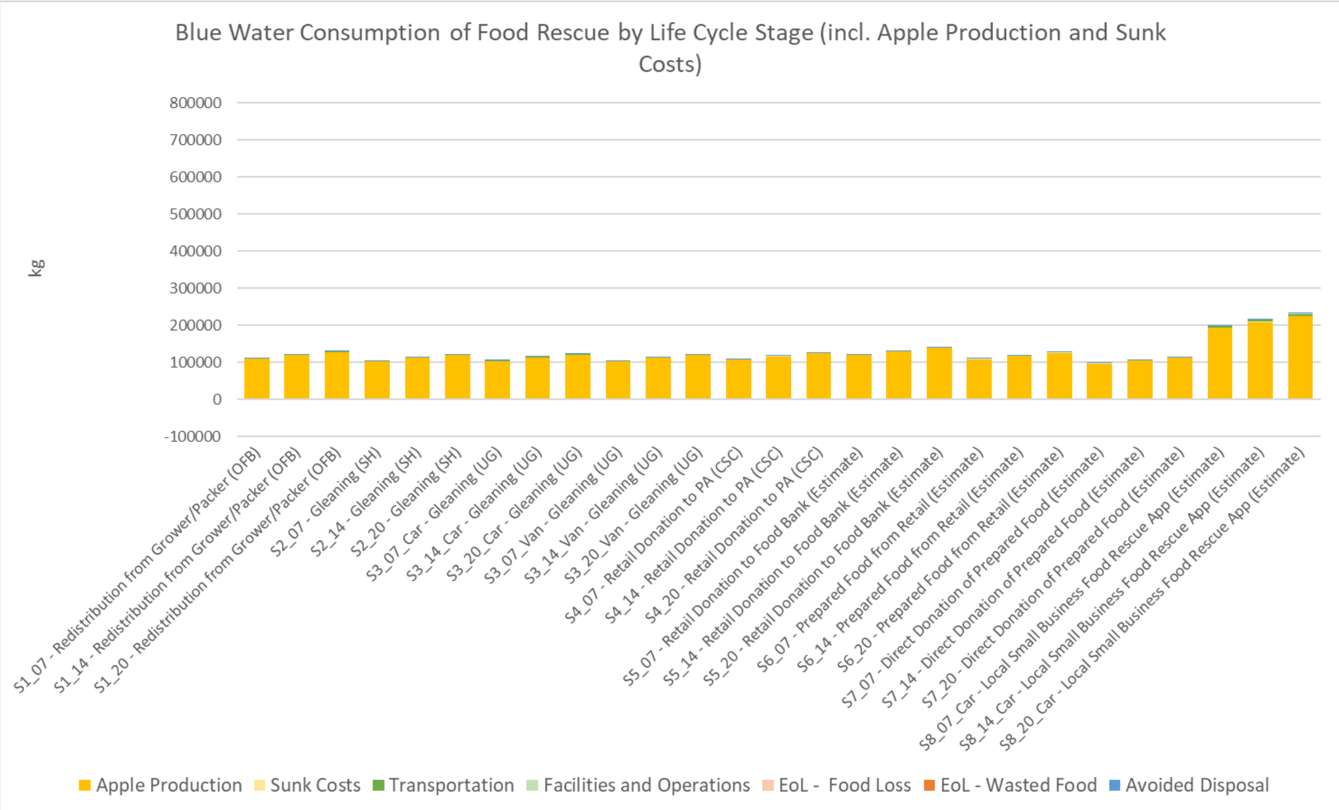

Figure 83 – Blue Water Consumption by Life Cycle Stage for All Scenarios including Upstream Production of Apples and Sunk Costs

8.1.9 Conclusions from Sensitivity Analysis

The addition of upstream food production impacts and estimated sunk costs vastly exceed the impacts of all food rescue activities in all impact categories. Overall, this led to increases in net impacts by many orders of magnitude, but did not lead to a meaningful shift in the relative comparisons across scenarios.

9. Appendix B – Life Cycle Inventory Parameter Values, by Scenario

Below is an excerpt of a table showing the specific variables encoded in the underlying LCI model. Because of the size of these tables and the inability to display them legibly in this report, an excel version of this information is provided as supporting information (see *S4. Appendix B – Parameter Tables for Food Rescue Scenarios.xlsx*). These tables are meant to provide a quick means of comparing the underlying model variables and seeing how they differ across each scenario. All of this information is contained in section 4 Life Cycle Inventory Analysis, but separated for each scenario.

			Farm Rescue (OFB)			Gleaning (SH)			Car Gleaning (UG)			Van Gleaning (UG)			Retail to PA (CSC - Fresh Allian			Retail to Food Bank (Estimated			Prepared Food from Retail (Est			Direct Donation of Prepared Fo			Small Business Food Rescue App			
Date of Last Update >	7/29/2019		S1_07 - Redistribution from Farm (OFB)	S1_14 - Redistribution from Farm (OFB)	S1_20 - Redistribution from Farm (OFB)	S2_07 - Gleaning (SH)	S2_14 - Gleaning (SH)	S2_20 - Gleaning (SH)	S3_07_Car - Gleaning (UG)	S3_14_Car - Gleaning (UG)	S3_20_Car - Gleaning (UG)	S3_07_Van - Gleaning (UG)	S3_14_Van - Gleaning (UG)	S3_20_Van - Gleaning (UG)	S4_07 - Retail Donation to PA (CSC)	S4_14 - Retail Donation to PA (CSC)	S4_20 - Retail Donation to PA (CSC)	S5_07 - Retail Donation to Food Bank	S5_14 - Retail Donation to Food Bank	S5_20 - Retail Donation to Food Bank	S6_07 - Prepared Food from Retail (Estimate)	S6_14 - Prepared Food from Retail (Estimate)	S6_20 - Prepared Food from Retail (Estimate)	S7_07 - Direct Donation of Prepared Food (Estimate)	S7_14 - Direct Donation of Prepared Food (Estimate)	S7_20 - Direct Donation of Prepared Food (Estimate)	S8_07_Car - Local Small Business Food Rescue App (Estimate)	S8_14_Car - Local Small Business Food Rescue App (Estimate)	S8_20_Car - Local Small Business Food Rescue App (Estimate)	Unit or Description
Food Type																														
Beef	Food Mixer	beef	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[0-1] enter fra
Dairy	Food Mixer	dairy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[0-1] enter fra
Grain	Food Mixer	grains	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[0-1] enter fra
Poultry	Food Mixer	poultry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[0-1] enter fra
Produce	Food Mixer	produce	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	[0-1] enter fra
Amount of Food Rescued																														
Weight of	GLO: Produc	Product	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	[kg] Enter kg o
Transport 1																														
Air_Distar	Transport 1	Air_Distar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[km]
Car_Distar	Transport 1	Car_Distar	0	0	0	0	0	0	19.77784	19.77784	19.77784	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19.77784	19.77784	19.77784	[miles]
Car_MPG	Transport 1	Car_MPG	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	[mpg]
Class2b_D	Transport 1	Class2b_D	0	0	0	0	0	0	0	0	0	19.77784	19.77784	19.77784	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[miles]
Class3_Dis	Transport 1	Class3_Dis	0	0	0	0	0	0	0	0	0	0	0	0	4.6	4.6	4.6	0	0	0	4.6	4.6	4.6	0	0	0	0	0	0	[miles]
Class4_Dis	Transport 1	Class4_Dis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[miles]
Class5_Dis	Transport 1	Class5_Dis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[miles]
Class6_Dis	Transport 1	Class6_Dis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[miles]
Class7_Dis	Transport 1	Class7_Dis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[miles]
Class7_Re	Transport 1	Class7_Re	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	40	40	0	0	0	0	0	0	0	0	0	[miles]
Class8a_D	Transport 1	Class8a_D	0	0	0	19.77784	19.77784	19.77784	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[miles]
Class8a_R	Transport 1	Class8a_R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[miles]
Class8b_D	Transport 1	Class8b_D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[miles]
Class8b_R	Transport 1	Class8b_R	299.9928	299.9928	299.9928	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[miles]
Ocean_Dis	Transport 1	Ocean_Dis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[km]
Rail_Dista	Transport 1	Rail_Dista	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[km]
RiverDow	Transport 1	RiverDow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[km]
RiverUp_D	Transport 1	RiverUp_D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[km]
Transport 2																														

Figure 84 – Excerpt of Parameter Values for all Scenarios with Apple Production

Endnotes

[i] State: In 2014, Governor Kitzhaber signed SB1541 which provides farmers with 15% tax credit on the wholesale price of their donation to food banks and hunger relief organizations (ORS 315.154 https://www.oregonlaws.org/ors/315.154)
Federal: In December 2015, Congress permanently expanded the enhanced tax deduction to all businesses through the Protecting Americans from Tax Hikes Act of 2015, a part of the 2016 omnibus budget, which allows allowing a business to deduct the smaller of (a) twice the basis of the donated food or (b) the basis of the donated food plus one-half of the food's expected profit margins.112 This is often close to twice the value of the general deduction. (H.R. 2029, 114th Cong. § 113(a) (2017) (codified at I.R.C. § 170(e)(3)(C)). The expansion of the enhanced deduction not only applies permanently to all business entities in future tax years, but it also applies retroactively for the 2015 tax year. H.R. 2029, 114th Cong. § 113(a) (2016) (codified at I.R.C. § 170(e)(3)(C))).
The 2016 omnibus budget also raised the cap on the amount of enhanced deductions that can be claimed, strengthened the formula for calculating the deduction, and clarified the method for determining the FMV of unsalable food products (H.R. 2029, 114th Cong. § 113 (2017) (codified at I.R.C. § 170(e)(3)(C)))