Chapter 12
Potential of Carbon Footprint Reduction within Retailers: Food Waste at Walmart in Mexico

Jorge Carlos Carpio-Aguilar, John Rincón-Moreno, and María-Laura Franco-García

Abstract Food wastage is a major problem at all supply chains stages that faces severe implications such as the environmental cost associated to the release of greenhouse gases and loss of monetary value due to inefficient use of resources. According to FAO (Food wastage footprint: impacts on natural resources: summary report. FAO, Rome, 2013) the global carbon footprint (CF) of annual food wastage is about 3.3 Gt carbon dioxide equivalent (CO_2e). This fact is altering the sustainability of the food supply chain. Although retailers as part of the food supply chain do not generate as much food waste as other stages, the food management at the retailers' stage is deeply encompassed. Their influence as the nexus amongst producers and consumers play a key role on the amount of food wasted throughout the supply chain. Therefore, the retail sector's strategies to reduce food wastage seem to be essential in order to pursue a sustainable economy and to combat climate change. Moreover, it is also aligned to the Sustainable Development Goal (SDG) number 12 from the United Nations "Ensure sustainable consumption and production patterns" that establishes an objective that "by 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains". In this scenario, one of the best practices of Walmart Inc. is the Project Gigaton. The objective of this project is to avoid the generation of one billion CO_2 tons throughout the Walmart' supply chain. In order to demonstrate best practices and to lead its suppliers towards CO_2 reduction initiatives, Walmart Mexico as one of the main markets

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of the company is implementing the "Zero Waste" (ZW) strategy on its operations. The ZW strategy at Walmart is aimed to manage efficiently any type of waste and also to consider the potential carbon footprint reduction due to a proper food waste management. Hence, this research sought to explore the potential of the carbon footprint reduction through different alternative food waste management routes aimed to lessen even further Walmart Mexico's environmental footprint. Consequently, in this chapter, the carbon footprint emissions were calculated based on each final destination, which includes: food donations to food banks, animal feeding, bio-digestion and composting. The findings of this analysis showed that every final destination had a reduction of the carbon footprint from food waste avoidance, which would help to support the development and actions needed to amplify the benefits of the ZW strategy in a broader scope and to contribute to the SDG.

Keywords Sustainable development goals · Zero food waste · Retailer · Greenhouse emissions reduction · Carbon footprint · Sustainable production and consumption

12.1 Introduction

Along the Food Supply Chain (FSC) an estimated of 30% of food produced for human consumption in the world is wasted even if it is still appropriate for human intake (FAO 2011). This alarming loss of edible food is a problem along the whole food supply chain in terms of capital and resources turning the food wastage costly as the chain progresses (Eriksson et al. 2016). This is caused due to the behaviour of food chain contributors (Cicatiello et al. 2016). As a consequence, FAO (2015) estimates that the worldwide carbon footprint of food produced and not eaten is 4.4 gigatons of carbon dioxide equivalent ($GtCO_2e$). This contributes to the current global environmental challenges such as climate change and loss of biodiversity, aggravated by the increasing global food demand projected for the upcoming years (Brancoli et al. 2017).

Hence, solutions on food waste burdens at a global scale are urgently needed to improve the food supply chain and to promote the efficient use of resources as well. The United Nations have been addressing this challenge by playing a key role dealing with these inefficiencies in the current food system through the support of the SDG 12. The SDG 12 is intended to ensure sustainable consumption and production patterns through the support of resource and energy efficiency. In particular, the SDG 12.3 is committed to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses by 2030 (United Nations 2017).

Although, the different actors involved in the FSC generate disturbing amount of food waste, the amount of food waste generated by retailers represent a minor fraction of the total food rejected (Brancoli et al. 2017). Despites this fact, some experts are pointing out the retailers' business strategy to be one of the responsible

actors for shaping the entire supply chain process due to the amplified retailers' bargaining power throughout the FSC as well as they are narrowly connected with producers and consumers (Claro et al. 2013; Eriksson et al. 2016), which makes them subject to investigate and to implement measures for food waste reduction (Scholz et al. 2015). Given the situation, tackling this issue at the retail level seems to be relevant in order to prevent food wastage.

As above mentioned, a well-defined target to contest the food wastage lead by the retailer industry would help to achieve a reduction of CO_2e emissions, as well as other future economic, environmental and social impacts. In fact this relationship is often mentioned in this chapter because there are evidences showing that food waste reduction has a positive effect on GHG emissions reduction. Thus far, retailers have implemented different approaches to reduce their carbon footprint throughout the FSC. Authors such as Hanson and Mitchell (2017) analysed the food sector identifying some of the best practices executed by food processors, food wholesalers, retailers (grocery and food) among others. For the purpose of this chapter, the attention is centred only on retailers' practices (approaches).

The number of large-scale food-retailers in 2016 accounted 172 at a global scale from which 17 are based in USA, 31 in Europe and 61 in emerging economies (Hanson and Mitchell 2017). Although retailer companies have plenty of competitors in the sector, one may think that the retailers are more resource efficient than other major industries towards a sustainable management of waste. However, some of their approaches according to Lipinski et al.'s report (2016) stress on good housekeeping actions: (i) provision of guidance on food storage and preparation; (ii) improvement of the food date labelling practices; (iii) acceptance of cosmetic standards more amenable to selling "imperfect" food. But there are other approaches that involve external actors as well, e.g. revision of promotions policy; facilitation of donation of unsold food; stimulation of innovation and scaling of promising technologies; creation of partnerships to manage seasonal variability and; increasing capacity building to accelerate transfer of best practices. Due to confidentiality of the information, these best practices cannot be associated to any specific retailer, but it can be said that they are well represented among the retailers analysed. It is a normal way to communicate by using associations that serve as platforms to debate, share knowledge and experience to deliver collectively positive impacts in the challenge of reducing 50% of food waste by 2030.

Nevertheless, a large retailer such as Walmart Mexico is committed to disclose data, to set a target to reduce food waste along its FSC, with the purpose to also reduce CO_2e emissions. It is not only that Walmart is aiming to reduce its environmental impact from its own operations; Walmart is also promoting the reduction of its supplier's environmental impacts. Therefore, Walmart Inc. launched the Project Gigaton[1] in 2016. The project's objective is to reduce emissions in its supply chain by 1 gigaton (1 billion metric CO_2 equivalent tons) between 2015 and 2030 (Walmart Inc 2017). To achieve this goal, Walmart is inviting its suppliers and

[1] Project Gigaton is a Walmart initiative to reduce 1 billion metric tons (a gigaton) of greenhouse gases from the global value chain by 2030 (Walmart Stores Inc. 2017).

organizations to reduce greenhouse gas (GHG) emissions in the supply chain by setting a GHG emissions reduction target associated to any of the next six pillars: energy use, waste reduction, packaging improvement, agriculture practices, deforestation avoidance or product use. The food waste reduction in the food supply chain operations shall be the scope for those parties interested in setting waste reduction targets. At this regard, the Project Gigaton is not explicitly linked to any of the SDG, but it can be assumed that by reducing GHG emissions derived from food waste this can also directly contribute to the SDG 12.3.

Thereby, it is essential to showcase one of those practices done so far within Walmart-Mexico (Walmex). At present, Walmex's objective is to avoid the generation of food waste whenever possible by seeking out a Zero Waste (ZW) objective by 2025. Currently, the waste that cannot be recycled, reused or composted is disposed of in authorized site for either urban solid waste or hazardous waste. The disposed waste still corresponds to 27% of the total waste generated (Walmex 2015).

Also, the food waste hierarchy established for Walmex provided the strategy with a ZW goal in the frame of Circular Economy[2] (CE). It was noted that the current organic waste stream at the store has relevant opportunities to be optimized. The framework used showed that besides the clear oversupply issues diagnosed, most of the food can be recovered through different stages ((i) reduction, (ii) donation, (iii) animal feeding, and (iv) anaerobic digestion, saving about 40% of the food waste management costs. However, this information does not provide enough data about the environmental impact. Thus, environmental indicators must be considered within food waste reduction goals to combat climate change and to achieve a sustainable economy.

Given the here above mentioned, this chapter intended to determine what is the potential of carbon footprint reduction from better management practices, food donations to food banks and anaerobic digestion as key strategies to diminish food waste at Walmart Mexico. This research aimed to analyse food wasted within Walmex in terms of GHG emissions and compare through the ZW strategy scenario in order to identify carbon footprint potential reduction and its relationship with the SDG number 12.

To this end, the usefulness of tools such as Environmental Protection Agency (EPA) Waste Reduction Model (WARM) that supports solid waste planners and administrations to track and voluntarily report GHG emissions reductions from several different waste management practices is a hands-on tool.

Therefore, (WARM) was used to estimate GHG emissions reductions from different waste management strategies. The tool calculated GHG emissions for the baseline scenario and for the alternative (ZW) waste management scenario which includes source reduction, recycling, combustion, composting, and landfilling. The

[2] Circular Economy: The Ellen MacArthur Foundation defines the CE as looking beyond the current "take, make and dispose" extractive industrial model; the CE is restorative and regenerative by design. Relying on system-wide innovation, it aims to redefine products and services to design waste out, while minimising negative impacts. (Ellen MacArthur Foundation 2018)

model calculated emissions in metric tons of carbon dioxide equivalent ($MTCO_2e$) and metric tons of carbon equivalent (MTCE) across a wide range of material types found in municipal solid waste (MSW).

The research is structured as follows: the steps needed to identify a carbon footprint potential reduction was detailed in Sect. 12.2. Then the methodological approach undertaken was described in Sect. 12.3. The findings and discussion as a result of the methodology applied to the case study was explained in Sect. 12.4. Finally, conclusions and recommendations were placed in Sect. 12.5.

12.2 Theoretical Framework

With the intention to describe the most important concepts used in this chapter, the terms of "food waste", "food waste management" and the "carbon footprint" in the context of food wastage at retail level are discussed in this section.

12.2.1 Food Waste

As mentioned in the introduction, food is lost at any stage of the food supply chain (FSC) from the initial stage of agriculture to the final consumption stage (Parfitt et al. 2010). Food loss and food waste rise from the activities associated to the different FSC stages, though food waste has been defined in a more general sense. For instance, FAO in 2011 defines "food waste as wholesome edible material intended for human consumption, arising at any point in the FSC that is instead discarded, lost, degraded or consumed by pests". Another relevant definition which was built upon the FAO's one, was the Stuart's (2009) who added the "edible material that is intentionally fed to animals or is a by-product of food processing diverted away from the human food chain". The Government Office for Science (2011) defined food waste at the final stages of the FSC (retail and final consumption) with a clear connection between food waste and behavioural issues.

12.2.2 Food Waste Management

The main intention to manage food waste is to reduce its amount; unfortunately, there is no upfront route for solving this challenge immediately. Ideally, the food waste could be reintegrated to the environment throughout biological processes but the amount generated exceeds the earth's capacity to prevent the releasing of GHG emissions; hence other routes must be explored. On that matter, some paths have been discussed in order to guide the most suitable options to achieve a reduction target. As an example, some scholars (Papargyropoulou et al. 2014) propose an

outline for the management of food waste throughout the food supply chain adopting the waste hierarchy framework developed by the European Union. We advocate for a dual categorization to classify what can be recovered as food surplus which in this scenario is considered as waste avoidance (e.g. reduction, donation and livestock feeding) and what can be used as food waste for the recovery step (energy recovery through bio-digestion).

Other authors (Parfitt et al. 2010) suggested that in the developed world, food waste has the greatest potential for its reduction with retailers, food services and consumers. For instance, educational campaigns to raise the consumer's awareness of the FSC and food waste's impact on the environment (GHG emissions from food production and consumption, as well as from its final disposal, depletion of natural resources and pollution). Additionally, the improvement of food labelling and better consumer understanding of labelling, also have food waste reduction potential. Therefore, setting the priorities and ways of food waste management is crucial as very often the main measure is the re-use of surplus food for human consumption to relieve food poverty.

12.2.3 Carbon Footprint of Food Wastage at Retail Level

According to the FAO (2013), a product's carbon footprint is the total amount of greenhouse gases (GHGs) emitted during its life cycle which is expressed in kilograms of CO_2 equivalent. This is relevant to determine the food waste at the retail level in terms of GHG emissions due to the environmental impact pattern of food waste in stores. Therefore, it is imperative to not only set environmental targets but also perform a proper measurement when considering food waste reduction goals (Scholz et al. 2015). Although some retailers indicated on their sustainability reports the amount of food waste in terms of weight, quantifying the environmental impacts may be a "*fashionable*" way to report on the importance of reducing food waste.

Nowadays, some sources of conversion factors are available which can be used to convert the weight of food waste to carbon dioxide equivalents. As pointed out by the World Resources Institute on the Food loss, waste accounting and reporting standard (2017), some guidance offer advice on methods and factors a company could use in converting the weight of food waste to greenhouse gas emission equivalents. Some of them are shown in Table 12.1.

12.3 Research Methodology

The methodological approach of this work is based on in-depth analysis of a case study whose description took our attention in Sect. 12.3.1. Since the main purpose of this chapter is to estimate the GHG emissions reduction through "ZW"

Table 12.1 Guidelines to convert weight of food waste to GHG emissions (own contribution)

Guidance	Description
WRAP's Ne estimates for household food and drink waste	Information about the approach used to calculate carbon dioxide equivalent emissions
ISO 14067	Guidance specifically related to greenhouse gas emissions
The Intergovernmental Panel on Climate Change (IPCC) fifth assessment report	Delivers conversion factors for different greenhouse gases to CO_2e
United States Environmental Protection Agency (US EPA) waste reduction model (WARM)	Various scenarios can be elaborated by entering data on the amount of waste handled by material type and by management practice. Then it calculates the greenhouse gas emissions reductions based on the alternative options for managing the waste. It is intended to support voluntary GHG measurement and reporting initiatives

management of food waste, it is relevant to select a tool/guideline to convert weight of food waste to GHG emissions, from Table 12.1, we selected WARM (Waste Reduction Model) which is further described in Sect. 12.3.2.

12.3.1 Case Description

In this section, a brief description of Walmart as the case to assess CO_2 emissions reduction from its food waste management is here presented. Last, with the purpose to provide sufficient details about Walmart's operations and related practices to its Zero Waste strategy at international and national levels.

12.3.1.1 Walmart International

Walmart started operations 50 years ago with a single store in Bentonville, Arkansas. At that time, it had the aspirational idea of "selling more for less". Nowadays, Walmart International operates over 11,695 stores under 59 different banners in 28 countries. It is the largest retailer in the world and one of its high aspirations is to become a leader in sustainability.

A relevant year in the Walmart's sustainability history was the year of 2005. In this year, Walmart launches for the first time its sustainability goals which were focused on the zero-waste philosophy, operations with renewable energies and selling products that display environmentally friendly characteristics. At this regard from its international operations, Walmart recognizes its potential impact at every single stage of the supply chain, and in responds to that, it has a strong policy to collaborate with its stakeholders. Examples of its type of collaborations can be here enlisted as follows:

- Supporting measurement and transparency in its value chain
- Reducing environmental impacts
- Providing affordable, healthier and safer food and products
- Supporting the dignity of workers everywhere

By the time the United Nations (UN) launched the SDG in 2015, there was also an international call (from UN) for action that invited stakeholders to collaborate in partnerships, especially to share knowledge, resources, expertise and technology. In responds to this call, Walmart joined the action network "Business for 2030" as well as the World Business Council for Sustainable Development and the Climate Smart Agriculture group. In the Business 2030 network, all the involved companies have to show their advances per goal in their commitments. For instance, Walmart is actively promoting actions to support the following SDG: Goal 2 – End hunger; Goal 5 – Achieve gender equality; Goal 7 – Ensure energy for all; Goal 8 – Promote economic growth and decent work; Goal 12 – Ensure sustainable consumption and production; and Goal 14 – Conserve Oceans.

From the initiative of reducing environmental impacts, additionally to minimizing waste in its own operations, Walmart is collaborating with its suppliers, non-profit organizations and communities in order to reduce food waste. As it was priory mentioned, Walmart supports the SDG 12 with the target of reducing its food waste by half at the consumer level and per capita by 2030.

12.3.1.2 Walmart Mexico (Walmex)

The operation of Walmart Mexico accounts more than 2350 stores with 6 different banners and 13 Distribution Centres. Walmex is currently employing almost 200,000 employees. Walmex has been continuously emphasizing its commitment with the environment, which is internally and externally announced, by developing strategies to reduce its operations impacts. Walmex also generates shared value with its customers, suppliers, employees and the society.

As Walmart Mexico is considered one of the main markets for Walmart International in terms of size and sales, it is also aligned to the main sustainability strategy that considers several environment goals: (i) the Zero Waste goal by 2025; (ii) 100% energy supply from renewable energies by 2020 and; (iii) promotes sustainable products.

Some of the results communicated in the Financial and Corporate Responsibility Report (2017) are that 91% of Walmex stores have energy supply by renewable energy sources (from five wind parks and two hydroelectric plants). Water consumption from stores was more than 2 million cubic meters of reused water from its 756 waste water treatment plants. Also 73% of the generated waste at the stores is already reused, recovered or recycled.

To achieve the 73% of waste reduction in 2017 Walmex confronted different challenges to manage the temporary storage, collection and final disposal alternatives from a total of 377,486 thousand tons of waste. The most difficult waste stream to manage is the one generated from food, due to the storage requirements and short

time periods for transporting before it start discomposing, and this limit the alternatives for reuse or dispose.

Walmex based its waste strategy in two different sources: Circular Economy principles and the model suggested by Papargyropoulou et al. in 2014. From those principles and model, Walmex has been working with projects that involve food waste reduction as a main priority, food donations for local food banks, and also with initiatives such as animal feeding and composting. In 2016, Walmex reduced the food waste from its stores by 13,000 tons, 27% less than the previous year, due to circularity practices applied by the different departments involved.

More details about the implementation of Walmex waste strategy can be further read in the publication of "Share, Optimize, Closed-Loop for food waste (SOL4FoodWaste)" written by Rincón-Moreno et al. (2018). The SOL4FoodWaste's authors argue that by "*using new disposal methods to avoid sending organic waste to landfill around the world is not a new phenomenon. However, applying organic waste management treatments under circular economy principles is becoming a profitable approach with social benefits which can be applied to most of the organic waste streams, including industrial and household wastes*" (Rincón Moreno et al. 2018).

12.3.2 GHG Reduction Calculations

From this section, the active participation of Walmex can be recognized in favour of the SDG accomplishment and its contribution to reduce GHG emissions from its own operations. At present, it is necessary to track their benefits in terms of GHG emissions reduction in order to establish the best suitable scenario as part of Walmex sustainability management. For this purpose, WARM was used due to its convenience to calculate GHG emissions from several different waste management practices. The model evaluates GHG emissions in metric tons of carbon dioxide equivalent ($MTCO_2e$) and metric tons of carbon equivalent (MTCE) for a baseline-scenario and alternative (ZW) waste management scenario. In this chapter, the alternative (ZW) scenario includes reduction in the source and anaerobic digestion. At this regard, WARM tool has a set of factors that were applicable depending on the type of waste management. The GHG emission factors that enable the calculations were developed by EPA following a life-cycle assessment methodology using estimation approaches established for national inventories of GHG emissions in the United States.

Three material (food waste streams) categories were considered in the online calculator, namely: (a) non-meat, which represents the average life cycle of fruits and vegetables, grains (bread), and dairy products; (b) meat, which represents the average life cycle of poultry and beef; and (c) mixed food waste, which represents an average of the materials noted before.

In the following section, the results obtained from GHG calculations are presented and explained.

12.4 Findings

As mentioned in the methodology section, two scenarios were used to verify the benefits in terms of GHG reduction of the ZW management scenario (combination of reduction in the source and anaerobic digestion in order to avoid landfilling (Sect. 12.4.2)). For comparison reasons, the baseline scenario (Sect. 12.4.1) is the one without alternative waste management (only landfilling).

12.4.1 Food Waste Characterization for the Baseline Scenario

"First-in-first-out" is the current food management method in the store, which is based on the assumption that all food products arriving on a specific time have the same shelf life span. Once the food is considered as waste, there are three different classifications to manage organic waste; (a) stolen/distorted (products in good conditions but incomplete or altered due to thieves' manipulation; (b) donation to those in need (products in good conditions but with aesthetically alterations in the package); and (c) food waste (rotten products, expiration date was passed, employees decided the landfilling of the food). For the purpose of this study, only the third category (food waste) was accounted for the calculations of GHG emissions as it has no declared additional purpose in the food value chain; in consequence it is either landfilled or composted without tracking the environmental impacts associated.

There are differences in the practices taken in the stores depending in the banner characteristics. As an example, once the organic products are taken away from the store-shelves, a green bag is used to collect the food labelled as organic waste to be transported into a refrigerated room or specific containers. This procedure takes place at least three times per day. After the collection of the food waste, this passes to an external collection supplier, who is in charge of the daily disposal of the food waste in landfill sites. According to the recorded information, six groups of food waste streams were identified: (1) food waste (meat only) (2) bread (3) fruits and vegetables; (4) dairy products; (5) food waste (non-meat); and (6) mixed food waste.

The data gathered throughout 1 year (2016) to elaborate the baseline scenario for this study was placed into the six categories mentioned in the previous paragraph. The final destination of the food waste was either put into a landfill or a composting process. However, the final destination was more inclined to landfilling as shown in Fig. 12.1. This is in spite of the acknowledged relevance to compost organic compounds of the food waste; only 4.83% of the total tons of food really enter to a composting process. It was also noted that fruits and vegetables had the largest share of food being wasted; this could be due to the shortest shelf-life-span of this category compared to meat products.

Accordingly, the rotation of fruits and vegetables in shelves becomes more frequent than the rotation of meat and meat-derived products, causing an alarming

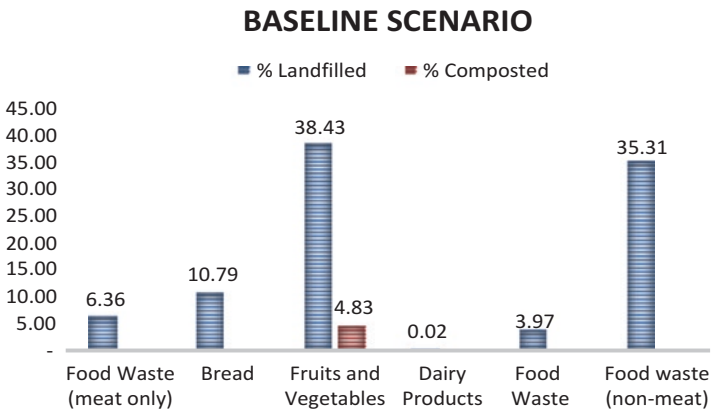

Fig. 12.1 Food waste management at Walmex (Own contribution)

increase on food waste being disposed of. Another issue preventing Walmex from doing a more aggressive composting option is related to the available area to compost the large amount of food being wasted and the logistic difficulties to deliver fertilizer and soil amendment to farmers.

12.4.2 Food Waste Characterization for the Alternative Scenario (Zero Waste Scenario)

The Zero Waste (ZW) scenario called alternative (ZW) scenario was delivered prioritizing food waste avoidance (reduce and feed people in need). The least desired option of the waste management approach corresponds to energy recovery (anaerobic digestion). This scenario was set according to the adaptation of the food waste hierarchy developed by Papargyropoulou et al. (2014). This provided a clear stance of the food conditions in the retail store, with the aim of properly assessing the environmental impacts of the ZW strategy.

The alternative (ZW) scenario for Walmart was selected due to its likelihood to be implemented as it was evaluated by Walmex in previous studies. Indeed, the ZW alternative scenario was described by Rincon Moreno et al. (2018) in the following stages towards: (a) improvement of food management (first-expired first-out); (b) donations to food banks, and; (c) anaerobic digestion. The first strategy is an approach intended to not only treat with oversupply issues but also to lengthen food shelf life span. The second strategy is part of a practice implemented by Walmart Foundation, long time ago, but now the store defines its own target regarding food donations. This strategy differs from the food waste classification "b" under Sect. 12.4.1 (donation for aesthetically reasons) as this classification is based mostly on canned food. This study accounted most of the fresh-food waste landfilled with a short shelf-life but still perfectly edible from a food safety standpoint. The third

component of the strategy is meant to substitute (commercial) natural gas with biogas generated by anaerobic digestion for heating and cooking operations. The main focus of Rincon et al. was to show the business case associated with each of the suggested components of the ZW scenario.

To move forward with this study, it was decided to assess also the environmental contribution of the alternative ZW scenario within the climate change challenges, such as the GHG reduction emissions. In other words, GHG were estimated in alignment to the global targets set by corporations on food waste avoidance, for our case at Mexican country level. With regards to this scenario (Fig. 12.2), the reduction for the two first methods accounted for 44% of food waste reduction and a 56% of food waste headed to anaerobic digestion or bio-digestion. In doing so, the alternative scenario eludes the landfill option.

The data gathered to elaborate the baseline scenario was necessary to quantify the beneficial effects in terms of GHG reduction when comparing with the alternative (ZW) scenario (Fig. 12.3). The six categories mentioned before, remained the same and the strategies were grouped in two (Source Reduced and Anaerobically Digested) as the WARM model does not distinguish the different approaches taken for the reduction stage.

As part of this analysis that, the fruits and vegetables group and non-meat food waste group were the largest groups diverted from landfill. This can be observed in both cases; the Anaerobically Digested and the Source reduced which comprised 'first-expired first-out' approach and donation. Although the least desirable option is anaerobic digestion, the high decomposition-rate of the fruits and vegetables group and non-meat food waste group makes extremely difficult to not use this option instead of source reduction as the elevated moral and quality standards impose these restrictions. Nonetheless, this scenario is fulfilling its objective by avoiding as long as possible to send the food to landfill sites.

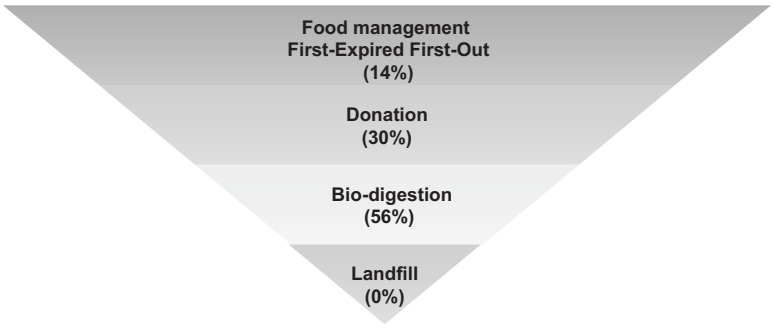

Fig. 12.2 Zero waste strategy of Walmex. (Rincon Moreno et al. 2018)

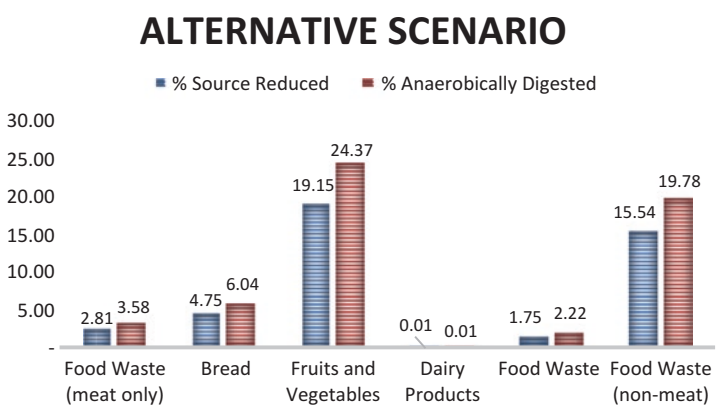

Fig. 12.3 Food waste management (Own contribution)

12.4.3 GHG Emissions from Baseline and Alternative (ZW) Food Waste Management Scenarios

The strategies set for both scenarios and the weight of food waste was used as an input for the WARM model. The model showed the metric tons of carbon dioxide equivalent ($MTCO_2e$) for each group and scenario. So far, the fruits and vegetables and the food waste (non-meat) group were accountable for almost emitting 42,000 $MTCO_2e$, making them answerable for the vast majority of GHG emissions in the baseline scenario. However, in the alternative (ZW) scenario the situation is the opposite. The values shown in Fig. 12.4 indicate a total emission reduction with the largest reduction corresponded to the meat-only group. The leading emission reduction on the meat-only group despites being one of the groups with a minor proportion of food being disposed of in terms of weight could be explained by one factor. Given that the WARM model uses U.S. inventories for its calculations, it is logical that vast reductions in GHG emissions are achieved for an industry that depletes natural resources in U.S. Therefore, any solution placed such as the alternative (ZW) scenario seems to be appropriate to tackle environmental challenges and specially to reduce harmful emissions from the meat and meat-derived.

The baseline food waste management (BFWM) scenario is highly harmful for the environment in all the groups of food waste. In contrast, the alternative food waste management (AFWM) scenario showed a total emission reduction (Fig. 12.5). This GHG emission reduction showed that the different strategies seemed effective to decrease the carbon footprint of food wastage.

In doing so, when comparing the two scenarios, it can be observed that the alternative scenario was avoiding the discharge of 54,192 $MTCO_2e$ for not landfilling the food waste as displayed in the baseline scenario. This scenario is also avoiding the releasing of 81,107 $MTCO_2e$ due to source reduced and bio-digested options. This implies that through the calculations made by the WARM tool the alternative (ZW) scenario showed GHG emissions savings. The total estimated carbon footprint

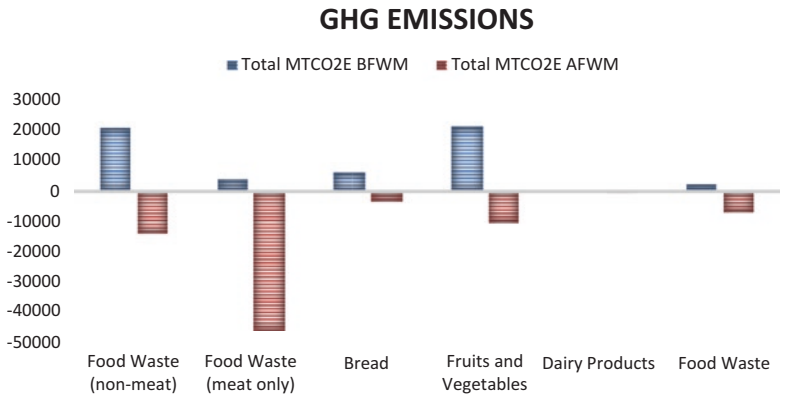

Fig. 12.4 Comparison of GHG emissions per group (Own contribution)

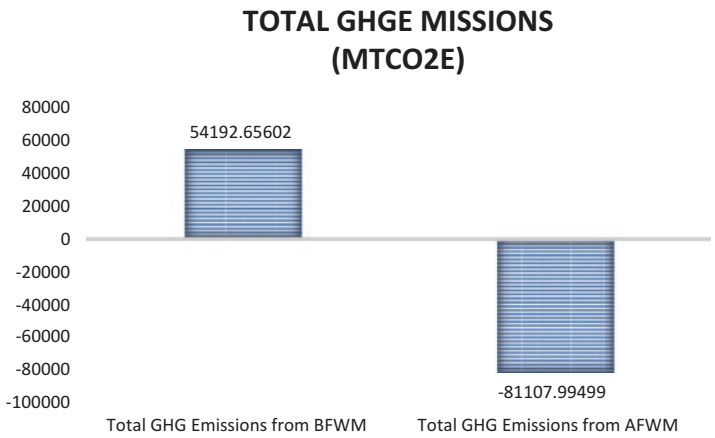

Fig. 12.5 GHG emissions (Own contribution)

reduction from the alternative scenario was of 135,301 $MTCO_2e$. To put it in perspective, if implemented the alternative scenario could avoid the annual emissions from 28,484 passenger vehicles, according to the WARM model.

12.5 Conclusions and Recommendations

The GHG emission reduction of managing food waste at the retailers' stage promoting the improvement of food management (first-expired, first-out), the donation of food discharged as bread, vegetables and fruits, and generation of energy through bio-digestion technological solutions was the main focus of this research. The driven research question was: what is the potential of carbon footprint reduction

from better management practices, food donations to food banks and anaerobic digestion as key strategies to diminish food waste at Walmart Mexico?

The findings showed that a well-set strategy based on environmental performance and focused on avoiding landfill was the logical approach taken in this study. When applied, all the groups of food waste placed in different zero waste strategies within the alternative scenario resulted in a clear CO_2 reduction. Furthermore, it was evident how high the environmental impact (as GHG emissions) of meat waste can be, even when it is recorded on small amounts.

Even further, the food waste management according to the ZW scenario can demonstrate best practices to be also applied by Walmart's suppliers participating in Project Gigaton. Therefore, we can conclude that any sort of initiative towards a ZW management of food is essential to reduce environmental impacts of food waste. Though, both source reduced, and bio-digested strategies proved to be suitable for GHG reduction, other scenarios might be considered in future research. Nevertheless, the scope of this investigation revealed that due to the characteristics of the food waste streams and those of Walmex, the alternative ZW scenario proposed can positively influence its general ambitions to reduce its negative environmental impact accordingly to the WARM model calculations.

In a broader perspective, it can be said that this research study shows the path to food retailers companies on how to adopt similar sustainability objectives and corporate responsibility strategies towards the achievement of the SDG, especially the goal 12 (sustainable production and consumption). In fact, the potential of a (ZW) carbon footprint reduction strategy was here estimated which proven to be a suitable solution for both: business and the environment.

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