Life cycle Impacts of food waste: the case study of Hotels in Heraklion Crete

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Life Cycle Assessment (LCA) is a methodology for assessing the cradle-to-grave environmental impact associated with a product, process or service - from the production of raw materials to the final disposal of waste. The LCA was developed to address issues not addressed by other environmental management tools, such as statutory environmental impact assessment. It has proven to be particularly useful as a technique for comparing two or more alternatives in terms of combined potential environmental impacts and ecological sustainability. The LCA is the focus of this work. The functional unit, in the specific case study, is defined as the management of food waste produced by 24 hotel units in Heraklion, Crete in 5 months from June 2019 to October of the same year. The environmental assessment includes nine environmental indicators and impact categories.

Food waste accounts for 22% of municipal solid waste and constitutes the largest percentage of municipal waste (EPA, 2019) even though it can be a valuable resource for "recycling" when managed reasonably and efficiently. However, it can adversely affect the environment when not properly managed, as food waste contains high levels of moisture and it is rich in protein and organic compounds, characteristics that cause odor problems and make it difficult to collect and transport food waste to a landfill. In addition, they greatly affect the environment, especially since their disposal in landfills is the predominant way of managing them (Kwon et al., 2007). This, of course, is not the only case in Greece, as the EPA (2019) estimates that in 2017, only 6.3% of food waste generated was diverted from landfills and used for composting.

Tackling food loss and waste (FLW) worldwide is vital to both improving food security and mitigating environmental pollution. Food loss or waste is directly linked to a significant waste of resources, such as water, land, energy, labor and capital (Scherhaufer et al., 2018). While there are numerous studies on FLW in nutrition, food safety, public health and the economy, there is only a small body of LCA research aimed at understanding the effects of FLW. LCA is a systematic approach used to assess the environmental impact over the life of a product or process, from the export of raw materials to their final disposal (Gao et al., 2018). Under FLW, the LCA is a methodology for addressing environmental impacts related to FLW management. It has also been used to assess the environmental impact of food waste management technologies/policies and to identify the best combinations of technologies/policies so as to maximize the environmental benefits (Mistretta et al., 2019).

The development of spatial and temporal LCAs is important in identifying effective FLW management strategies, since existing FLW laws and policies vary in spatial and temporal contexts, while best management practices are influenced by season and location. ISO 14.040 defines a module as "the quantified performance of a product system for use as a reference unit" (ISO, 2006). The operating unit of this study is the waste generated by the selected hotel units of Heraklion, Crete from June 2019 to October of the same year and the selected products correspond to 141.7 tons of food waste during this period. Although various factors determine the system boundary - such as the purpose of the study, the assumptions made, and the intended audience - ISO 14.040 suggests that the conditions used to define the system boundary must be determined and justified in the field of study (ISO, 2006). Therefore, defining the system boundary of an LCA is vital to the LCA model as it ensures the comparability of studies (Omolayo et al., 2021). Target and scope definition is the first phase of a standardized LCA, which includes a description of key options such as the reason for the LCA, a detailed definition of the product or process and its life cycle, and a description of the system boundaries (Curran, 2017).

Waste management approaches can have significant implications for identified life cycle impacts. For the case study, the current practice of waste management in Heraklion, Crete in the given period of time is the final disposal of waste in landfills. The LCA included the fractions of food waste generated with high frequency and in large quantities (Table 1), as these were considered to be the most important statistics. The selected waste fractions were then categorized according to the following table to perform LCA analysis. At the same time, the distinction of food by category -what is written in the brackets of the above table – are the subcategories taken into account for the present study. Meat waste was considered, to simplify the model, as fresh meat waste, while for sausages and minced meat, the meat content was distributed in the relevant meat fraction (beef, pork or chicken).

Table 1: Categories of food waste in case study

	Quantity (kg)
Vegetables (tomato peels, pumpkin peels, seeds, grass residues)	20,077.91
Bakery products (bread, crust, breadsticks, baguette, biscuit, nut, bun)	8,232.79
Fruit (orange peel, stones, apple core)	63,996.89
Cooked foods (pies, pizza, spaghetti, risotto)	35,185.29
Meat, fish, seafood (burger, steak, bones, fish, sausages, shellfish, shrimp)	7,069.33
Dairy products (excluding milk) (cheese, yogurt, cream)	1,136.21
Spices, sauces, herbs (mayonnaise, mustard, oregano, pepper)	494.73
Desserts (ice cream, pastes, tarts, pastries)	318.93
Small snacks and sweets (wafers, nuts, sweets, jam)	127,24
TOTAL	136,639.32

The modern view of FLW management provides new opportunities to achieve a shift from a linear to a circular economy (Mak et al., 2020). Its main goal is to provide reusable resources to provide societies with abundant energy and materials, rendering recycling and reusing waste as resources. While FLW prevention and use strategies, supported by existing and emerging FLW policies, promote the circular economy, it is not clear whether these policies and management models are environmentally sustainable (Teigiserova et al., 2020). There is a critical need for a symmetrical environmental impact assessment of different FLW management alternatives.

Life cycle interpretation is the last phase of an LCA where the results of the other phases are interpreted and further analyzed based on uncertainties and variables within the studies and on spatial and temporal explanatory evidence or hypotheses made in the study (Hauschild et al., 2018). Thus, interpretations must take into account the controls of completeness, consistency and sensitivity. Uncertainty indicates that LCA outcomes depend on standard options in the modeling process and occurs because different options have different outcomes. It is worth noting here that the current practice of waste management in Heraklion, Crete in the given period of time is the final disposal of waste in landfills.

The LCA is a powerful tool for understanding the impact of food waste prevention, rescue and recycling activities that have already been used in different ways in different countries and at different stages of the food supply chain. More consistent in methods, LCA research findings can not only improve our understanding of the impact of various existing wasted food reduction practices but also serve as a critical tool for predicting and assessing the impact of future food waste interventions and policies. Common LCIA categories were examined with ILCD 2011 Midpoint+ V1.11 / EU27-2010 equal weighting method and include: climate change, ozone depletion, human toxicity, with no cancer effect, human toxicity with cancer effects, particulate matter, ionizing radiation HH & E, photochemical ozone formation, acidification, terrestrial eutrophication, freshwater eutrophication, marine eutrophication, freshwater ecotoxicity, land use, water resource depletion, mineral fossil & ren resource depletion, according to the software used– SimaPro 9.1.1.1. It was found that the predominant categories in terms of environmental impact are meat and fish, fruits and cooked meals, which have an even greater contribution, as their processing to be edible has multiplied their energy and environmental footprint. Further references will be made in the presentation of the respective article.

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